SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1915.

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SCIENCE ABSTRACTS.

Section A.—PHYSICS.

APRIL 1915.

GENERAL PHYSICS.

377. *Venturi Meter.* **Camichel, Eydoux, and Lhériaud.** (Comptes Rendus, 160. pp. 28–31, Jan. 4, 1915.)—A paper discussing the merits of the Venturi tube for measuring the flow of liquids. If p_1, p_2 are the pressures at points of the tube where the diameters are d_1, d_2 respectively, Bernoulli's theorem easily leads to the result $q = \lambda\pi d_1^2 d_2^2 \sqrt{2g(p_1 - p_2)}/4\sqrt{d_1^4 - d_2^4}$, or $q = \lambda a\sqrt{p_1 - p_2}$, where q is the quantity flowing per sec. past any point and λ is a factor less than unity, depending on the internal friction of the liquid. Herschel's experiments, for velocities up to 15 m. per sec. in the narrow part of the tube, gave values for λ ranging from 0·995 to 0·954. If the velocity was not less than 12 m. per sec., Herschel found that λ did not fall below the value 0·96. The authors of the present paper have made a series of experiments with a Venturi tube of 800 mm. diam. and for which $d_1^2/d_2^2 = 4$, the flow ranging from 60 to 160 litres per sec. The velocity of the water in the narrow part of the tube was for the greatest rate of flow about 11 m. per sec. The results show that for these experiments $\lambda = 1$, the experimental errors being less than 1 %. Other experiments by Soulom on a tube of diam. 1·2 m., the flow ranging from 100 to 3000 litres per sec. and the velocity in the narrow part reaching a value of about 11 m. per sec., gave values for λ always between 1·00 and 0·98. Comparison of the results obtained with the Venturi tube and with a weir of the Bazin type showed good agreement. The results never differed by more than 4 %, and generally did not exceed 2 %. For small rates of flow, particularly for laboratory installations, Venturi tubes are specially suitable, and will give results with a direct-reading manometer accurate to within less than 1 in 200. A. W.

378. *Adiabatic and Isothermal Compressibilities of Liquids.* **D. Tyrer.** (Chem. Soc. J., Trans. 105. pp. 2534–2553, Oct., 1914.)—The adiabatic compressibility of a large number of liquids has been measured by reading the displacement of a mercury capillary when the pressure was reduced from 2 atmos. to 1. The experimental error was only about 0·1 %. In order to determine the isothermal compressibility from the adiabatic value, use was

made of the thermodynamic equation: $\beta = [\alpha + T(dv/dt)^2]]/vC_p$, where β and α are the isothermal and adiabatic compressibilities. This method of measurement has great advantages over earlier methods, in many of which the observations were described as isothermal, but were really adiabatic, whilst others were intermediate between these two conditions and useless for exact determinations. T. M. L.

379. *Plastic Bending of Metals.* **F. L. Hopwood.** (Phil. Mag. 29. pp. 184–190, Jan., 1915.)—The sagging of thin, uniform rods in the form of cantilevers under the influence of their own weight is divided into the following three cases: (*a*) a position of equilibrium will be taken up in which the external forces are balanced by internal elastic forces or (*b*) plastic yielding will occur and the sag will steadily increase with time, the rod coming slowly to rest in an approximatety vertical position, or (*c*) the plastic yielding will take place so rapidly that, owing to its momentum, the rod will bend until its free end passes below the clamp and oscillates about a point below the clamp. The author has obtained some empirical results for case *b* by taking, at intervals, numerous photographs of lead wires allowed to bend under the influence of their own weights. The results show that the equation to the curve assumed by soft metals under these conditions is of the form $x = ay^n$. The significance of a and n is discussed, and it is shown that n is a parabolic function of the time of sag. F. C. A. H. L.

380. *Fragility of Iron at different Temperatures.* **Goerens** and **Hartel.** (Zeitschr. Anorg. Chem. 81. pp. 130–144, 1913. Rev. de Mét. 11. E pp. 571–577, Aug., 1914.)—Charpy impact tests have been carried out on two commercial dead-mild steels at temperatures varying from −75° to 1000° C. Temperature-resilience curves show that at low temperatures the resilience is very low and that it increases as the temperature rises to that of the room. At this point it reaches a maximum and then falls again until it attains a minimum at about 500° C. The resilience then increases until it reaches a second and well-defined maximum at about 600° C., above which temperature it falls rapidly. The curves show no peculiarities at the transition-points of steel. F. C. A. H. L.

381. *Collapse of Cylindrical Rods.* **L. Lecornu.** (Comptes Rendus, 160. pp. 43–47, Jan. 11, 1915; *Errata*, p. 110, Jan. 18, 1915.)—Discusses the theory of the sudden collapse by flexure which takes place in thin rods acted upon by stresses that are within the elastic limit. This collapse must be due to the existence in the rod of a state of unstable equilibrium, and the point at which instability occurs is deduced from a consideration of the potential energy of the rod and its load, P. The equilibrium is stable so long as $P < 4\pi^2 EI/l^2$, *i.e.* in the case of a cylindrical rod of radius r, so long as $h < \pi^2 r^2/l$, where h is the displacement of one end of the rod with respect to the other, and l is the total length of the rod. At this point the rod becomes unstable as regards bending whilst remaining stable as regards direct compression.

J. W. T. W.

382. *Form of a Suspended Tape and the Effect of Stiffness.* **A. E. Young.** (Phil. Mag. 29. pp. 96–127, Jan., 1915.)—Gives a detailed mathematical investigation of the corrections to be applied to lines measured with a surveyor's steel tape, with special reference to Maclaurin's work on the effect of stiffness [Abs. 1607 (1904)]. The assumption that the tape will take the form of

a catenary presupposes perfect flexibility. This is never attained in practice and in the case of a long, thin tape of length l and weight w per unit length, stretched by a tension whose horizontal component, T_0, is so large that the sag is quite small, the correction for stiffness is $w^2 l EI/T_0^2$, assuming the ends freely supported at the same level. This correction, which is to be subtracted from the catenary sag correction, is, for practical purposes, quite inappreciable. If the ends be clamped horizontally the stiffness correction is increased to $(8w^2l^2/8T_0)\sqrt{EI/T_0}$, the magnitude of which is such as to be worth considering in base-line measurements. If the chord connecting the ends of the tape is not horizontal, the sag correction may be readily obtained by writing $w \cos \psi$ for w in the ordinary sag correction formula, and the same remark applies with sufficient accuracy to the correction for stiffness. Here ψ is the angle of slope of the chord. A mathematical discussion of the correction for this case leads to the general conclusion that if an adequate tension be used, and the lengths of the bays in sag are not extreme, the effect of stiffness on the sag correction is quite negligible. An investigation of the catenary *at any angle* follows, and the expression obtained for the sag correction is $w^2l^3 \sin^2 \zeta/24T^2 \left\{1 \pm (wl \cos \zeta/T)\right\}$, where T is the full end tension, and ζ the angle the chord makes with the vertical. The upper or lower sign is used according as the tension is applied to the upper or lower end of the tape.

The effect of elastic extension is next examined, and as it is of a smaller order than the catenary curve correction, it is justifiable to assume the tape to have taken the catenary form unstretched and then to add the effect of stretch. The expression thus found for the effect of stretch in a tape of cross-section A is $(Tl/EA)\left\{1 - (w^2l^2/12T^2)\right\}$. The first term is the amount by which the tape is stretched when it lies flat, while the second term represents the contraction due to a diminution in the mean tension owing to the curvature. The effect on the sag correction of using tapes of different density is also examined, and results are quoted which confirm experimentally the theoretical formulæ deduced. [*Errata* (on cover of March issue.).]

J. W. T. W.

383. *Present Aspect of the Hypothesis of Compressible Atoms.* **T. W. Richards.** (Am. Chem. Soc., J. 36. pp. 2417–2439, Dec., 1914.)—In this undelivered presidential address the author summarises his views on the theory of compressible atoms. Instead of assuming that each atom is surrounded by a "sphere of influence" considerably larger than itself, he prefers to regard this "sphere of influence" as being for all practical purposes the only thing that can be usefully described as the "volume" of the atom. The variation of b in van der Waals' equation suggests that this volume is compressible: even when the a-factor is insignificant, as in gaseous helium, the volume b diminishes from 12 cm.^{3} at 0° C. to 10·4 cm.^{3} at 100° C. This indicates that the "volume" of the atom diminishes, probably because the higher velocity drives the atoms together more closely when they collide with one another, thus producing a diminution in the "collision-bulk" of the atoms. Unlike van der Waals, he assumes that the bulk of the molecules, when not compressed, may be about equal to the critical volume but that this volume is already diminished by compression due to cohesion as soon as the gas liquefies. The small compressibility of liquids and solids, and their small contraction on cooling almost to the absolute zero, indicate that the atoms in liquids and solids are more closely packed than has usually been supposed; this is, however, quite in accord with the theories of Barlow and Pope as to the close packing of the atoms and molecules in crystals.

The theory is also applied to compression (or diminution of volume) produced by chemical affinity. The compressibility has been measured for about 40 elements, and has been shown to follow the atomic volume curve somewhat closely. Strontium and lead are about equally compressible, but there is a contraction of 32·6 cm.^{3} on making strontium chloride as against 20·1 cm.^{3} in making lead chloride; this difference is attributed to unequal affinities. On the other hand, the alkali metals give the following compressibilities and contractions:—

	Li	Na	K	Rb	Cs
Compressibility...............	9·0	15·6	31·7	40	61
Contraction	17·6	21·5	33·1	36·3	53·6

The affinities do not differ very widely, and the increasing contractions are attributed to the increased compressibility of the metals with the larger atomic volumes. T. M. L.

384. *Form of a Liquid Drop suspended in another Liquid of Variable Density.* **J. Rice.** (Phil. Mag. 29. pp. 149–154, Jan., 1915.)—In Plateau's experiment, in which a drop of oil is suspended in a mixture of water and alcohol having the same density as the oil, evaporation of the alcohol from the surface of the mixture produces a density-gradient in the latter, the drop of oil then flattening into an oval form. Assuming that the density of the liquid surrounding the drop varies continuously with the depth and making various restrictions, the author shows analytically that the form of the drop is approximately that of the oval of a quartic curve [see Rayleigh, Abs. 1663 (1914)]. T. H. P.

385. *Motion of Solid Bodies in Viscous Liquids.* **V. N. Alfimov** and **B. P. Weinberg.** (Russian Physico-Chem. Soc., J. 46. 2. pp. 66–74, 1914.)—The study of this question involves: (1) the preparation of inexpensive, transparent liquids with coefficients of internal friction ranging from 10^3 to 10^9; (2) the elaboration of a method for tracing the trajectory of the separate elements of the liquid when a solid body passes through it; (3) the fixing of conditions of experiments on the motion of a solid body in a viscous liquid under the action of a constant force, such that the influence of the walls of the vessel may be investigated. Mixtures of small proportions of colophony or gum dammar with turpentine form suitable liquids, but when larger amounts of the resin are present difficulties are met with, owing to the low thermal conductivity, the high viscosity, and the ready decomposability of the fused resin, and also to the large number of bubbles formed. A vessel is described which permits of the preparation of 30 kg. of the mixture. It consists of an outer oil-bath containing cylinder oil and furnished with a Liebig's condenser and a thermometer. This bath is heated underneath, and acts as a jacket to a second, smaller vessel provided with a stirrer, a condenser, and a thermometer. Measurements have been made of the velocity with which a ball 1·9 cm. in diam. falls through one of the above mixtures at temperatures of about 16–17° and in tubes 9·2, 6·5, and 5·0 cm. in diam. The mean velocities found are 0·0345, 0·0242, and 0·0234 mm. per sec. respectively. From these numbers, Ladenberg's formula, $v_R = v_{R=\infty}/(1 + 2{\cdot}4r/R)$—where r and R represent the radii of the ball and tube respectively—which refers to small values of the ratio r : R, gives for $v_{R=\infty}$ the values 0·0518, 0·0413, and 0·0454 mm. per sec. respectively. Modification of the above formula in accordance with Kuznecov's observations (Ibid. 45. 2. 1913) leads to the values 0·0486, 0·0407, and 0·0471 for $v_{R=\infty}$. T. H. P.

386. *Resistance of the Air to Falling Spheres.* **G. A. Shakespear.** (Phil. Mag. 28. pp. 728–734, Nov., 1914.)—Hollow spheres of celluloid were allowed to fall from various heights in the Chamberlain tower of the Birmingham University, the time of fall being noted for each height. The falls used were 770, 1456, 2142, 2828, and 3800 cm. When the effective density of the sphere was not too great, the terminal velocity was reached at each of the last two distances, and was equal to the quotient of the difference of these distances and the difference of the times of fall. It was assumed that at this velocity the resistance of the air was equal to the weight of the sphere in air. The effective density of the sphere was varied by introducing into it different quantities of small lead shot. In this way the resistance at different velocities was found. In order to find how the resistance depended on the diam. of the sphere, similar spheres of different diams. were loaded so as to fall 3800 cm. in equal times as observed by letting them fall simultaneously on to a calico sheet stretched horizontally near the floor. The falls were timed by an electrically-maintained tuning-fork, which inscribed, by means of a metallic style, a sine curve on a rotating drum covered with smoked paper. By induction coils records were made on the paper both when the ball left the "dropper" and when it was received by the "catcher."

For spheres of diams. varying between about 2 and 7 cm., moving with velocities between about 500 and 2000 cm./sec., the resistance (R) of the air was found to be nearly proportional to the square of the velocity (V) and to the area of the diametric plane (S) of the sphere, but in the usually accepted equation, $R = KSV^2$, the factor K, instead of being constant was found to increase both with S and with V; its value being about one-fifth the density of air. E. H. B.

387. *Steady Motion of Liquid Ellipsoid, and Oscillations of Jacobian Figure.* **R. Hargreaves.** (Cambridge Phil. Soc., Trans. 22. No. 5. pp. 61–85, Oct. 15, 1914.)—A purely mathematical investigation, the results of which are made more generally accessible by embodiment in a series of diagrams representing the domains of steady motion for a homogeneous liquid ellipsoid under its own gravitation, an inspection of these being sufficient to show what kind of steady motions are possible for an ellipsoid of given shape. In respect to the Jacobian figure of equilibrium, an interesting result obtained is that in its steady motion about two axes (Riemann's Case II), the conditions laid down by Riemann are entirely superseded by the condition of positive pressure. G. W. DE T.

388. *Harmonic Motion of a Rigid Body.* **G. F. C. Searle.** (Cambridge Phil. Soc., Proc. 18. pp. 31–38, Jan., 1915.)—The experiment here described is designed to illustrate the principles of harmonic motion in the case of a rigid body vibrating about a vertical axis under the influence of the torsion of a wire. If K be the moment of inertia of the body about the axis of rotation, μ the couple required to produce 1 radian twist, then the period T of the oscillations is given by $T = 2\pi\sqrt{K/\mu}$. In the experiment, K is found by weighing and measuring the rigid body, and μ is determined from a series of measurements of the angle through which the lower end of the wire is turned by a series of couples applied statically. The angles are measured with a goniometer which gives, up to about 0·25 radian, an accuracy of 1/400 radian. The periodic time is calculated by the above equation, and this time is compared with the value obtained experimentally. The agreement between the observed and the calculated values of T forms an experimental test of the accuracy of the dynamical principles employed in the calculation. A. W.

389. *Form assumed by Red Blood Corpuscles.* **J. Rice.** (Phil. Mag. 28. pp. 664–670, Nov., 1914.)—The author shows mathematically that, on the basis of a fairly reasonable assumption as to the manner in which the surface-tension of a film alters with its thickness, the observed form of the corpuscles is a physically possible one in the sense that it is one for which the surface energy is less than for any surface derived from it by a small deformation consistent with constant volume. G. W. DE T.

390. *Shape of the nearly Spherical Drop which falls through a Viscous Fluid.* **S. Saito.** (Tôhoku Univ., Sci. Reports, 2. 5. pp. 179–201, Feb., 1914.)—Mathematical.

391. *Equilibrium of an Isotropic Elastic Rod of Circular Section.* **J. Dougall.** (Roy. Soc. Edinburgh, Trans. 49. No. 17. pp. 895–978, 1913–1914.)—Mathematical. A complete solution is given of the problem of equilibrium of an infinite circular cylinder subjected to the action of a force in any direction applied at a single point of the body, whether at the surface or in the interior. L. H. W.

392. *Further Remarks on the Stability of Viscous Fluid.* **Rayleigh.** (Phil Mag. 28. pp. 609–619, Oct.; *Erratum*, Dec., 1914.) [See Abs. 10 (1914).]

393. *Isostatic Reduction of Gravity Observations.* **F. R. Helmert.** (Preuss. Akad. Wiss., Ber. 14. pp. 440–453, 1914.)—Formulæ are developed for the discussion of pendulum observations at various stations from the isostatic standpoint, frequent reference being made to the results of Hayford in the United States. C. P. B.

394. *Variation of Gravitation Intensity.* **W. Schweyder.** (Preuss. Akad. Wiss., Ber. 14. pp. 454–465, 1914.)—Discussion and derivation of formulæ for reduction of observations of variations of gravitation intensity over the earth's surface, chiefly in connection with the elastic theory of deformation. C. P. B.

395. *Calculating the Coefficients of a Trigonometrical Series to represent a given Series of Observations of a Periodic Quantity.* **C. H. Lees.** (Phys. Soc., Proc. 26. pp. 275–278; Disc., p. 278, Aug., 1914.)—In view of the number of alternative methods which have been suggested for calculating the coefficients of the terms of a trigonometrical series to represent a number of observations of a periodic quantity, the author points out that the Fourier method gives the most probable values of the coefficients, since it makes the sum of the squares of the errors at the points of observation a minimum. AUTHOR.

396. *Turbulent Flow.* **W. Sorkau.** (Phys. Zeitschr. 15. pp. 582–587, June 1, 1914.)—The author has had his experiments [Abs. 28, 1090 (1913)] repeated with an improved, more carefully blown apparatus. The measurements were carried out by T. Ugarte, and the results are tabulated for comparison with those previously obtained. L. H. W.

397. *Accelerated System of Reference from the Standpoint of the Relativity Principle.* **F. Kottler.** (Ann. d. Physik, 45. 4. pp. 481–516, Oct. 1, 1914.)—Mathematical treatment. [See Abs. 1484 (1914).] E. H. B.

398. *Tornado of South Wales and the West of England, October 27, 1913.* **H. Billett.** (Meteorolog. Office, Geophys. Mem. No. 11. [15 pp.], London, 1914.)—A travelling storm of the thunderstorm type was traceable along a line running almost due north and south from the South of Devon to Cheshire. This storm developed into a tornado of exceptional violence for a distance of about 11 miles up the Taff Valley in Glamorganshire, for about an equal distance in Shropshire, and for about 5 miles in Cheshire. The storm track was very narrow, ranging in South Wales from 50 yards wide at its southern end to 300 yards at the northern extremity. Many houses were damaged by the storm, walls being blown down and roofs removed. Some corrugated iron sheets forming the roof of a co-operative store were carried to a considerable distance, one being found wrapped round a telegraph pole from half a mile to one mile away. Two walls lying perpendicularly across the track of the storm were blown down, the eastern part falling to the northward and the western part to the southward, while in one of the two about 15 yards in the centre was left standing. This seems to prove the cyclonic character of the wind circulation. The rate of travel of the disturbance is found to be about 35 miles per hour over the length of the track. Notwithstanding the severe lightning which was experienced but little damage was done which could be ascribed to this cause. Several observers in different districts reported the occurrence of globular lightning. A pungent sulphurous smell was also widely noticed. A barograph close to the track in South Wales showed a very rapid fall of 0·3 in. of mercury. It is pointed out that such a change of pressure if applied suddenly to the outside of a closed building must produce an effect similar to an explosion from within, and this would account for the blowing-out of walls of houses, removal of roofs, and similar effects.

There is no doubt that the storm was a genuine tornado of the type common enough in parts of America, though of rare occurrence in this country. J. S. Di.

399. *Polarisation and Absorbing Power of the Atmosphere.* **A. Boutaric.** (Comptes Rendus, 160. pp. 75–77, Jan. 11, 1915.)—In a former note [Abs. 1123 (1913)] it has been shown that the absorbing power of the atmosphere for all solar radiations varies inversely as the polarisation of the diffused light of the sky. Observations for 3 years are now given and discussed, with confirmation of the view originally taken. It is hoped that a formula will be found permitting of the exact evaluation of the absorption from observations of polarisation, vapour tension, and extent of atmosphere traversed. C. P. B.

400. *Total Radiation received on a Horizontal Surface from the Sun and Sky at Mount Weather, Va.* **H. H. Kimball.** (Monthly Weather Rev. 42. pp. 474–487, Aug., 1914.)—The Callendar pyrheliometer measures the difference in electrical resistance, due to difference in temperature, of two horizontal grids of Pt-wire exposed to solar and sky radiation, the one of which is blackened and the other left bright. A continuous record of this difference of resistance is made upon a chart. It is not strictly correct to assume that such readings on the chart measured with a uniform scale are directly proportional to the intensity of radiation received, and in order to calibrate the instrument the author has made comparisons with a Marvin pyrheliometer which had been carefully checked against the Smithsonian standards. It is found that the readings of the Callendar instrument are dependent on the quality of the radiation received, tending to be too high when there is a small proportion of short wave-length radiation, as when the sun is low in the sky. The factor for obtaining radiation intensities from scale readings in the case of one instrument tested is found to vary from 0·0274 at sun's zenith distance 80° to 0·0188 at zenith distance 79·8°. A table is given showing the appropriate values of the factor, (1) for different zenith distances of the sun, and (2) for different degrees of cloudiness of the sky. These factors are used in determining the hourly amounts of radiation received at Mount Weather during 1912, 1913, and 1914. The total radiation per cm.^{2} of horizontal surface per day with the clearest sky varies from 250 cals. in Dec. to 765 in June. The average daily radiation in summer is about 68 % of that received on the clearest days at the same time of year, and in winter it is about 63 %. The extreme values of the radiation received from the sun and sky in one minute on to a horizontal surface of one sq. cm. are 0·77 cal. in Dec. and 1·55 cals. in June. The extremes at normal incidence from the sun alone vary from 1·87 in Jan. to 1·50 in May and Sept., a surprisingly small annual variation. The diffuse sky radiation received on a horizontal surface at noon on cloudless days averages for the whole year about 25 % of the direct solar radiation on to the same surface. Considering the energy received on the earth's surface, a rate of radiation of 1·50 cals. per cm.^{2} per min., a not uncommon rate at midday in summer, is equivalent to nearly 1·2 h.p. per square yard. J. S. Di.

401. *Nitrogen and Chlorine in Rain and Snow.* **W. K. Knox.** (Chem. News, 111. pp. 61–62, Feb. 5, 1915.)—A continuation of the work of Wiesner. Porcelain-lined pans, 20 in. diam., were put out in the open near the centre of the village of Mount Vernon, Iowa; there are no factories in the community. The observations were made on 48 samples collected from Oct., 1913 to June, 1914, in which 17·75 in. of rain and 11·5 in. of snow (equivalent to 0·95 in. of rain) fell altogether. The chlorine, nitrates, nitrites, free ammonia, albuminoid ammonia, and sulphate were determined, and are tabulated in parts per million and in amounts per acre; no sulphate was found after May, so that the sulphate was probably due to the sulphur in the coal fuel. H. B.

402. *Bottom Currents in Lake Ontario.* **E. M. Kindle.** (Am. J. Sci. 39. pp. 192–196, Feb., 1915.)—The observations presented in this paper relate to data which were obtained as an incidental result of the study of certain phenomena associated with sedimentation. Previous work on the surface currents by Harrington, relates almost entirely to the "body currents" or those connected with the general outflow or set of the water toward the outlet and their modifications by surface currents due to the prevailing winds. These were only of slight importance as geologic agents. Wholly independent of these gentle surface and outfall currents, there are in Lake Ontario subsurface and bottom currents which are at times effective and powerful agents for the transportation of sediments. Their erratic appearance and behaviour is the result apparently of the varying wind and barometric pressures which produce them. The author's observations were made on the south side of Prince Edward Island in Wellington Bay. Both the velocity and direction of the currents were greatly altered while the atmospheric conditions remained unchanged at that locality, thus showing they bore no relation to local air-currents. H. H. Ho.

403. *Theban Earthquake of October 17, 1914.* **D. Iginitis.** (Comptes Rendus, 159. pp. 1009–1013, Dec. 28, 1914.)—Four times within the last 62 years has Thebes been devastated by earth movements, and the present

paper gives an account of the more important data which these earthquakes have furnished. Eastern Greece appears to have been a region of extreme seismic activity from earliest times, and forms part of the zone involved in a great geological movement initiated towards the close of the Tertiary epoch. A noteworthy circumstance is the non-production of holes or cracks during the last 8 disturbances, although in 1858 large rock masses were detached in the vicinity of Thebes. In striking contrast the Athenian region has been very stable, the feeble movements registered having in most cases originated from without. Details of the tremors are given at some length.

H. H. Ho.

404. *Isostasy and Radio-activity.* **G. F. Becker.** (Science, 41. pp. 157–160, Jan. 29, 1915. Paper read before the Geolog. Soc. of America, Dec., 1914.)—The purpose of this paper is to point out some apparent discrepancies between the observations of geodesists on isostasy, and the inferences which some radiologists have drawn as to the great age of certain minerals. Isostatic investigations are reviewed from those of Laplace to those of Herschel, Pratt, Hayford, Bowie, and Helmert. Much evidence exists to show that equilibrium is nearly or quite complete at a depth between 110 and 140 km., and the mass beneath that level must be almost free from strain and can have cooled but little from its primeval temperature. The discussion of radiological work includes Rutherford's nuclear theory of the atom, and van den Broek's discovery that the place of an element in the periodic table is determined, not by its atomic weight, but by the number of positive electric charges carried by the nucleus and termed "the atomic number." A single atomic number may be borne by each of several substances which may have different atomic weights and, in the case of radio-active substances, different stabilities, but which are inseparable by ordinary chemical or physical properties. Soddy calls the members of a group of elements bearing a single atomic number, and occupying therefore a single place in the periodic table, "isotopes." This revolutionary doctrine has been supported by T. W. Richards, who finds the atomic weight of lead from uraninite deposits to be lower than that of ordinary lead. The discovery of isotopism sufficiently explains the great discrepancies in the ages of minerals as computed from the Ur-He ratio and the Ur-Pb ratio. These ratios no longer seem adapted to age determinations, and, while growing knowledge of atomic structure may eventually lead to trustworthy methods of age determination from radio-active phenomena, yet in the meantime other methods must be resorted to.

In computing the temperature distribution of a cooling globe which owes a part of its heat to compression, or to initial temperature, and another part to radio-activity, the author has assumed various ages and computed other conditions corresponding to the actual heat-emission of the globe, such as the depth of the eutectic level (*i.e.* the level at which the rock temperature most closely approaches the melting-point at the prevailing pressure), the thickness of the radio-active shell, and the proportion of the surface gradient due to the radio-activity. The two special cases of 68 and 1814 million years for the earth's age are discussed at some length. The latter seems incompatible with other features of the problem, but the former requires the eutectic level to be at a depth of 121 km., which coincides with Hayford's data. Moreover, the greater age implies a thick shell of more than 200 km. to extend from the compensation level downward to and beyond the eutectic level, and to have cooled after solidification through about 600 deg. The author deems it impossible for such a layer to cool through 600 deg. without setting up large strains. The smaller age presents no such difficulty, for it is easy to show that only a very small amount of cooling has occurred below its eutectic level. Furthermore, in this case, the level of compensation acquires a definite and intelligible physical interpretation, since local fusion would bring about compensation.

The author opines that the determination of the level of compensation limits both the age of the earth and the amount of radio-active matter in its outer shell. H. H. Ho.

405. *Progress of Astronomical and Mathematical Research.* **F. Schlesinger.** (Science, 41. pp. 109–117, Jan. 22, 1915. Paper read before the Am. Assoc. for Advancement of Science, Philadelphia, Dec., 1914.)—The author traces the influence on scientific progress of the varying intimacy of the mathematician and astronomer during different epochs. In astronomy the greatest strides during recent times are attributed to the concentration of effort, resulting in the establishment of great telescopes for the prosecution of definite investigations, or a single group of related problems; also to the widely distributed system of co-operation between the different institutions, whereby results obtained at specially equipped centres are available generally for study. Regarding the possibility of co-operation between astronomers and mathematicians, the desirability of this is illustrated by the work to be done in the study of spectroscopic binaries, mainly in the analysis of the conditions of stability possible for systems of two or more bodies revolving round a common centre of gravity and producing eclipses. Other studies requiring co-operation are those dealing with the evolution of celestial bodies. C. P. B.

406. *Energy Distribution in Spectrum of Globular Cluster* M_3. **E. Hertzsprung.** (Astrophys. J. 41. pp. 10–15, Jan., 1915.)—A spectrum of the integrated light of M_3 was obtained with the U.V. Zeiss triplet at the Potsdam Observatory on Feb. 2, 1914, using an objective prism of 7·5° deviation. This was measured on a Hartmann microphotometer, the spectrum being examined throughout in steps of 0·1 mm. In order to reduce the scale readings of the microphotometer comparisons were made with the plate showing stars of the north polar region taken through an objective grating for photometric standardisation [see Astron. Nachr. 4452]. The results are tabulated showing the density distribution on the negatives with respect to the K line (λ3933), and curves are plotted to illustrate the values found. A very striking similarity is seen to obtain between the energy distribution in the spectrum of the cluster and that of a typical F-type star.

Visual comparisons of the integrated light were also obtained for investigating any possible absorption of light in celestial space. C. P. B.

407. *Anomalous Dispersion in the Sun.* **C. E. St. John.** (Astrophys. J. 41. pp. 28–71, Jan., 1915. Mount Wilson Solar Observatory, Contrib. No. 93.)—From time to time various papers have been published by Julius ascribing the majority of solar phenomena to effects of anomalous dispersion, in several cases illustrated by statistical treatment of results obtained in solar investigation by St. John, Adams, and others. St. John now replies at length to the question, giving very full discussion to each section. With regard to the influence of proximity of strong and weak lines, the actual mean residuals give results opposite to those quoted by Julius, and are opposed to the require-

ments of the anomalous dispersion theory. Further, tested by standards deduced from the homogeneous group of observations to which they are to be applied, the lines in the near neighbourhood of stronger lines show no systematic differences from lines not so situated. It is shown that influencing lines showing very strong anomalous dispersion exert no greater effect upon neighouring lines than those showing very weak anomalous dispersion. New measurements of weak lines in the broad shadings of the strongest lines in the solar spectrum show no systematic differences for lines near them, nor any systematic progression in the displacements as the strong lines are approached. The general displacements of the Fraunhofer lines to the red are a minimum for lines of medium intensities—a result opposite to that required by the theory. Classified by their displacements in the solar atmosphere the iron lines fall into the same classes as when classified by pressure shift. The general conclusion is that the deductions from the anomalous dispersion theory are not supported by the observational data. C. P. B.

408. *Systematic Errors in Measurement of Stellar Photographs.* J. C. **Kapteyn.** (Astrophys. J. 41. pp. 77–80, Jan., 1915.)—In the general determination of parallax and proper motion by means of photography one of the most troublesome sources of error is that depending on the magnitude of the stars involved. To get rid of the difficulty the author proposes that plates should be specially taken through screen-plates consisting of extra-focal images of the same star-field; thus each pencil of rays forming an image of the focus will have passed through a screen more or less dense in relation to its magnitude, and by ascertaining the proper practical conditions it is thought that the resulting images of all stars might be photographed of equal size. The measurement of these images should then be free from systematic error due to differences of magnitude of the stars themselves. C. P. B.

409. *Stellar Radial-velocity Observations.* **Küstner.** (Astron. Nachr. No. 4750. Nature, 93. p. 623, Aug. 13, 1914. Abstract.)—The radial velocities of 227 stars of spectral type F to M have been determined by the author during the period 1908 to 1913, with the 30-in. refractor at Bonn. The values obtained are compared with those obtained by Campbell at the Lick Observatory: the values for 151 stars are available, and Küstner determines the mean differences of the observed radial velocities, Lick minus Bonn, for each spectral class. The differences are regarded as errors of the Bonn observations. L. H. W.

410. *Systematic Errors of Stellar Radial Velocities.* **S. Albrecht.** (Astrophys. J. 40. pp. 473–480, Dec., 1914.)—Since it was recognised that the wave-lengths of numerous lines in stellar spectra vary progressively as a function of the spectral type of stars [Abs. 199 (1907)] it has been suspected that a large proportion of the systematic differences in radial-velocity results may be due to the selected wave-lengths used in the reductions. This applies to the relative radial velocities for the different types as determined at any one observatory, and especially to the systematic differences between radial velocities for each type considered separately as determined at different observatories. Kustner's recent list of radial velocities [preceding Abs.] supplies material for a critical test of the question. The discussion is illustrated by tabulations of the differences of wave-length found for certain selected lines

in the various stellar types by different observers. From the values given for Campbell's K term in the radial velocities for spectral types it seems not unlikely that this is in part due to these differences in wave-length of the standard lines used in the reductions. Further refinement is needed in the determination of the laboratory wave-lengths before the question can be carried further. C. P. B.

411. *Photometric Measures of the Zodiacal Light.* **M. Hall.** (Monthly Weather Rev. 42. pp. 311–317, June, 1914.)—In a former note an account was given of observations of the intensity of the light at different distances from the sun compared with the light of the sky at the same zenith distance at places as free from stars as possible [Abs. 1220 (1914)]. The work was continued during Feb. and April, 1914, and the observations are now discussed in detail, the results being shown in tables giving the dimensions and brightness for each date of observation. C. P. B.

412. *Influence of Local Atmospheric Cooling on Astronomical Refraction.* **J. Larmor.** (Roy. Astron. Soc., M.N. 75. pp. 205–210, Jan., 1915.)—The object of the note is to find whether the residual Kimura annual variation in latitude, symmetrical round the earth's axis and amounting in amplitude to about 0·06″, is of such magnitude as may reasonably be ascribed to changes of refraction. The view receives support from the fact that the variation term attains its extreme values at the winter and summer solstices. Formulæ are given for determining the changes in refraction due to distortion of the atmospheric strata by different temperature gradients. C. P. B.

413. *Irregularities in the Earth's Rotation.* **J. Larmor.** (Roy. Astron. Soc., M.N. 75. pp. 211–219, Jan., 1915.)—In the investigation of the moon's orbital motion there remains an outstanding irregularity, composed of a fluctuation of 13 secs. of arc on each side of a mean in a half-period of about 140 years, combined with a like fluctuation of about 3 secs. of arc in the shorter half-period of 35 years. In the present note the author examines the possibility of attributing all or part of these discrepancies to irregularities in the earth's velocity of rotation on its axis, due to the rearrangement of surface masses. C. P. B.

414. *Total Eclipse of the Sun, August* 21, 1914. **H. S. Jones** and **C. R. Davidson.** (Roy. Astron. Soc., M.N. 75. pp. 125–134, Jan., 1915.)—The expedition from the Greenwich Royal Observatory was located near Minsk, Russia, and arrangements were made to obtain photographs of the form of the corona on a large scale; spectographic records of the chromospheric and coronal spectra, and photographs of the corona on a small scale through green coloured screens, to obtain evidence of the distribution of coronium in the corona. Excellent results were obtained. The form of the corona belonged to the type corresponding to the epoch of increasing sun-spot activity, showing resemblances in some respects to the coronas of 1898 and 1901. A notable feature is that the polar streamers around the sun's north pole are much more extensive than those around the south pole, which is the reverse of what was seen during the 1901 eclipse. The north polar streamers are not symmetrical about the sun's axis. The northern streamers consist of slender, sharply defined single plumes, whereas the southern are composed of broader diffused streamers, occurring more or less in bunches. The spectograph had a quartz optical train, with single lenses of 3 in. aperture and 38 in. focal length. Good definition was secured from λ3000 to λ4100 by using a curved film.

Provision was made for photographing a comparison spectrum of iron on the plate for wave-length determination. About 120 lines are measurable between λ8100 and λ8300. The spectrum of the corona was not very successful.—**A. Fowler, E. H. Hills,** and **W. E. Curtis.** (Ibid. pp. 117–124, Jan., 1915.)—Details are given of the programme of the observers who proposed to occupy the station at Kiev, Russia, but owing to the outbreak of the war the expedition had to be abandoned. The chief instrument consisted of a powerful concave grating spectograph, mounted on the Littrow principle, adjusted to give the third-order spectrum from λ3640 to λ4400 on a photographic plate 18 in. × 3 in., thus having a dispersion of 1·69 Å. per mm. Arrangements were made to obtain on the same plate a comparison spectrum of the iron arc for determination of wave-lengths. C. P. B.

415. *Transit of Mercury, November* 6–7, 1914. **A. A. Rambaut.** (Roy. Astron. Soc., M.N. 75. pp. 182–191, Jan., 1915.)—The transit was observed under fairly favourable conditions at the Radcliffe Observatory, Oxford, records being obtained with three instruments. Times of all four contacts were taken, and photographs of the sun's disc were taken at intervals with the 24-in. refractor. Full details are given of the times observed and the deduced diameter of the planet. No surface details of any kind could be detected on the disc of Mercury. C. P. B.

416. *Ninth Satellite of Jupiter.* **S. B. Nicholson.** (Lick Observatory, Bull No. 265, 1915.)—The ninth satellite of Jupiter was discovered photographically with the Crossley reflector at the Lick Observatory on plates taken July 21 and 22, 1914. The plates were being taken to find positions for the known faint satellites, and the new one was discovered in the course of the reductions. Approximate elements of the orbit are given, based on 9 days' observations, from which it is decided that the object is a true satellite. Its motion, like that of the eighth satellite, is retrograde, and other elements are very similar for the two satellites. C. P. B.

417. *Figure of Jupiter.* **W. de Sitter.** (K. Akad. Amsterdam, Proc. 17. pp. 1047–1050, Feb. 27, 1915.)—Investigating the form of the planet Jupiter by the analysis of the potential function of a body possessing axial symmetry, and employing the values obtained by observation for the time of rotation, it is concluded that the deviation from the ellipsoid consists of a protuberance along the equator, produced by the increase of the rotation velocity, and a depression in mean latitudes. The deviations calculated would be far beyond the reach of direct micrometrical measurement. C. P. B.

418. *Determination of Fundamental Photographic Magnitudes.* **J. Halm.** (Roy. Astron. Soc., M.N. 75. pp. 150–177, Jan., 1915.)—Referring to the necessity of determining the true law of photographic action before it is possible to obtain reliable photometric data from photographic observations, the systems of Schwarzschild and Kron are discussed in some detail. For a certain intensity of radiation, the photographic action I*t* required to produce a desired actinic effect assumes a minimum value, and Kron defines this particular intensity as the *optimal intensity* of the plate. If in astrophotometric work we are only dealing with intensities much smaller than this optimal intensity, the method advocated by Schwarzschild is free from objection. It is found, however, that this only applies to comparatively faint stars. Tables are then given for use in the employment of Kron's elaborated method. The hope is expressed that by the careful development of this system it may be possible to determine photographic magnitudes, based on

exact photometric principles, independently of any data supplied by the results of visual photometry. An example is given in the case of the reduction of three plates of the Pleiades. C. P. B.

419. *Photographic Doublet for Star Positions.* **F. Schlesinger.** (Am. Phil. Soc., Proc. 53. pp. 303–306, Aug.-Dec., 1914.)—Up to the present time the standard instrument for determining positions of stars photographically has been the achromatic objective, one of the drawbacks of which is the small field, rendering necessary a great number of comparison stars. It has been known for many years that a doublet lens would give a much larger field with good definition, but this form has for some reason or other not been adopted, chiefly because it was thought that various errors might be introduced. Experiments have been undertaken at the Allegheny Observatory to test the problem, and it is considered that the doublet lens may, with certain precautions, be employed for the most delicate investigations of star cataloguing. A number of star regions covering about 25 square degrees each were photographed in duplicate, first with the centre of the plate at the centre of the region, then with the edge of the plate in that position, and comparison measures made of the stars on each. A catalogue of 7100 stars is to be published from the measures. C. P. B.

420. *Tables for Reduction of Photographic Measures.* **B. L. Newkirk.** (Lick Observatory, Publ. 7. pp. 49–157, 1913.)—Reduction tables, based on Turner's rigorous formulæ, are given for use in the investigation of photographic surveys of star positions, etc. Special notes are given in the text for controlling the method of computation. A further note is appended containing an investigation of the constants of a Repsold measuring apparatus. C. P. B.

421. *Tables of Astronomical Refraction.* **R. T. Crawford.** (Lick Observatory, Publ. 7. pp. 159–216, 1913.)—It has been recognised for some time that a revision of the tables for computing refractions was necessary, the values given by Bessel and those from Pulkowa both being too high. For the present investigation special observations were made with the 6·4-in. meridian circle of the Lick Observatory, two independent sets being made under different meteorological conditions. The method adopted amounted practically to the converse of Talcott's latitude method, the assumed latitude being eliminated to determine the refraction. The greatest disadvantage lies in the necessity of considering the declinations of the stars as known, but this has been minimised by only observing fundamental stars. Details are given of the system of reduction, and the resulting tables for determining refraction for any position. C. P. B.

422. *Number of Dark Stars.* **F. A. Lindemann.** (Roy. Astron. Soc., M.N. 75. pp. 178–182, Jan., 1915.)—An attempt is made to estimate statistically the number of dark stars on the hypothesis that new stars are due to collisions of stars. Using certain assumed data, it is found that there may be 4000 times as many dark stars as bright ones. C. P. B.

423. *Comparison of Stellar Magnitude Scales.* **H. H. Turner.** (Roy. Astron. Soc., M.N. 75. pp. 143–148, Jan., 1915.)—A discussion is given of the magnitudes of the stars in the Astrographic Catalogue published by the Perth Observatory, suggesting that it is important to arrange a system of comparison between the magnitude scales adopted by the different observatories taking part in the work. Indications are given of important variations in the distribution of stars of given magnitude, especially with respect to the plane of the galaxy. C. P. B.

LIGHT.

424. *Determination of Light lost in Stellar Spectrographs.* **C. D. Perrine.** (Astrophys. J. 40. pp. 481–482, Dec., 1914.)—The proportion of light lost in a spectrograph may be determined photographically by comparing the exposure time necessary to produce an ordinary trail, at the telescope focus, of the same length, width, and density as that of the spectrum, with the exposure time of the spectrum, for the same star. As in general the spectrum will not be of uniform density, its average should be determined by measures at a number of points. Care should be given to the selection of plate and the method of development, and if possible the exposures should be on the same plate. In addition, the loss for different widths of slit and qualities of "seeing" should, if possible, be obtained for comparison, as the image is known to be considerably diffused by atmospheric disturbances and instrumental irregularities. The method would also be of value with all forms of slitless spectrographs. C. P. B.

425. *Telescopic Vision of Illuminated Surface.* **F. W. Vorhies.** (Astrophys. J. 40. pp. 311–325, Oct., 1914.)—The theoretical discussions on the subject of telescopic vision by Stoney [Abs. 221 (1909)] have been taken up experimentally, with the view of finding what practical limits are to be expected in the visibility of fine detail. The artificial object was an illuminated aperture crossed by wires varying in diam. from 0·08 to 0·62 mm. It is shown that the quality of the image is not greatly improved by increasing the size of the telescope aperture indefinitely, but of course smaller details may be seen with the larger telescopes. The effect of atmospheric disturbances was studied by producing convection currents of heated air in the optical beam. C. P. B.

426. *Experiments with a Moving-lamp Photometer.* **C. C. Trowbridge and W. B. Truesdell.** (Phys. Rev. 4. pp. 289–305, Oct., 1914.)—The author describes a mechanism for producing a uniform motion of a lamp away from and towards the photometer, a device being provided for recording the exact position of the lamp at which photometric balance occurs. The method is specially applicable to experiments on the brightness of phosphorescent substances, where the brightness alters rapidly while observation is in progress. Errors so caused may amount to as much as 15 % for rapid decay. An analysis is also made of the part played by personal judgment of the observer, retinal fatigue, and reaction time of observer and of recording device. Data supplied shows that the fatigue of the retina of the eye varies according to the individual, being markedly different in the case of three persons tested. J. S. D.

427. *Contrast Photometer.* **A. H. Pfund.** (Phys. Rev. 4. pp. 477–481, Dec., 1914.)—A very fine line of division between the two sections of the photometric field of this instrument was obtained by using a piece of platinised glass acting as a mirror, in which one of the photometric surfaces is seen by reflection, the other being seen by direct vision. A refinement is the introduction of two tinted glass wedges, absorbing approximately 2 % of light in their thickest regions, which are inserted in converse positions in the respective fields of view. By this means a contrast effect is introduced, the balancing position giving equality of brightness in the centre of the field, but a somewhat darker region in the opposite corners. It is claimed that this device, assisted by the fine line of optical division obtained as described above, gives rise to great sensitiveness; with lights of the same colour a mean error in setting the photometer of 0·1 %, and an error in candle-power measurement of 0·88 %, were recorded. Experience also showed that very consistent results were obtained even with sources of light differing considerably in colour. By causing the mirror-surface to rotate, the element of flicker is introduced. The photometer so used was also very sensitive, an average deviation in c.p. of only 0·6 % being found even when comparing a red light with a green one. J. S. D.

428. *Sensitometry of Photographic Papers.* **L. A. Jones, P. G. Nutting, and C. E. K. Mees.** (Phot. J. 54. pp. 842–856; Disc. 856–859, Dec., 1914.) —It is most desirable to apply to printing materials the methods which Hurter and Driffield applied with so much success to the materials used for making the negative, and several attempts have been made to do so, without, however, any satisfactory results having been obtained. The chief difficulty in obtaining satisfactory results is in measuring the silver deposit. In films and plates this deposit is determined by measuring the light transmitted by it, and several attempts have been made to apply such methods to papers. These attempts, however, not only fail because of their intrinsic difficulty, but because the results obtained on a paper by transmitted light are not comparable to the effects observed when the paper is viewed by reflected light. This is due to the fact that the surface reflection—which is an all-important thing in reflected light—is counted as absorption in measuring transmitted light, while the internal absorption of the deposit plays a much smaller part in determining the intensity of the reflected light than when the transmitted light is measured. In order to obtain the best results a photographic print must be viewed entirely by light that is diffusely reflected from its surface. The great difficulty hitherto met with in measuring the light reflected from paper has been the absence of any suitable instrument for measuring the light reflected from small areas. This difficulty is overcome by the use of the Bechstein illuminometer, which is modified to make it suitable for the measurement of the light reflected from small areas of paper prints. The arrangement of this illuminometer is shown diagrammatically and fully explained. It is found that curves plotted between reflecting power and the logarithm of the exposure do not satisfactorily represent the data, and therefore another form for expressing the results is adopted. The form adopted is log 1/R, where R is the reflecting power expressed decimally (not in per cent.). If then we call this value the density for reflected light and designate it by D_r, then $D_r = \log 1/R$. This form is the most rational way in which to express the relative brightness of reflecting areas, since the visual sensation produced is proportional to the logarithm of the brightness, and not to the brightness itself. This expression, it will be noted, is identical in form with that used under the name of "density" for light-transmitting media, such as photographic plates. The density (log 1/R) of any portion of a print depends upon three factors: surface reflection, reflecting power of paper stock on which the emulsion is coated, and the mass of silver in the deposit.

The exposure of the paper is first considered, then the question of constants. It is found that matt papers should give a reading of max. black of 1·10 as a minimum for soft papers to 1·35 for strong papers; velvet papers, from 1·35 to 1·50; and glossy papers, from 1·50 to 1·80. The results given on "contrast" are not intended to be exhaustive, being only the preliminary values and merely indicative of the kind of results obtained. By the term "rendering power" as applied to printing papers is meant the capacity of a paper to reproduce a scale of exposures by a series of densities having proportional values the same as exist in the exposure scale. It is obvious from the inspection of the characteristic curves of printing paper that this condition is realised only throughout a part of the total scale, the portion giving correct proportional rendering being the straight line portion. The length of the straight-line portion measured along the exposure axis is called the "latitude" of the paper. In order to render proportionately the scale of gradation of a negative correctly, the curve of a paper should be a straight line from one end of its total scale to the other. It is shown that rendering power = latitude × 10/total scale. The results obtained for the papers measured vary from 2·5 to 5·0. They are given in a table, and have been found to agree very well with conclusions reached in practical photography. If the standard exposure of the paper is known, and also the max. density of the negative used, the current exposure can be computed according to the following formula: $E = E_s/\text{antilog}(2{\cdot}0 - D_m)$, where E is the correct exposure, E_s the standard exposure, and D_m is the max. density of negative. The "constants" of a paper, chosen as being important and sufficient to represent approximately the characteristics of a paper, are as follows: Max. density ($D_{\text{max.}}$); gamma (γ); total scale (S); latitude (L); rendering power 10L/S (R); standard exposure (E_s). The following problems are also investigated:—Adaptation of paper to negative; the effect of development on the curve of photographic papers; papers other than developing-out papers. A. E. G.

429. *Absorption of Light in Metals and Non-conductors.* **G. Jaffé.** (Ann. d. Physik, 45. 8. pp. 1217–1252, Dec. 8, 1914.)—A theoretical paper. (*a*) *Metals.*—The Lorentz theory of metallic conductivity is extended to the case of periodic fields. The optical constants deduced from the conductivity depend upon the ratio of frequency to number of collisions per sec., but numerically are nearly the same as Drude's. The formula for the variation of reflecting power with wave-length gives results in agreement with experiment, and permits of calculating the number and mean free path of electrons. (*b*) *Non-conductors.*—Absorption coefficient for the case of feeble absorption is deduced from a comparison of the Lorentz and Drude damping (latter proportional to velocity, former to number of collisions per sec.). This gives the same result as Lorentz calculated inside a narrow absorption line; but outside the damping depends on frequency.

For a gas with only one natural ultra-violet frequency the absorption coefficient is independent of the frequency, as is shown by observations on the atmospheric absorption of light. J. M.

430. *Absorption of Light by Water containing strongly Hydrated Salts.* **E. J. Shaeffer, M. G. Paulus,** and **H. C. Jones.** (Phys. Zeitschr. 15. pp. 447–453, May 1, 1914. Chem. News, 110. pp. 223–224, Nov. 6, and pp. 235–237, Nov. 13, 1914. Translation.)—Aqueous solutions of non-hydrated salts have very nearly the same absorption as pure water, having the same depth as the water in the solution. Strongly hydrated salts have in general much less absorption than a layer of water equal in depth to the water in the solution. A number of new examples have been added to those recorded in an earlier paper. T. M. L.

431. *Scattering of Light by the Air.* **J. Cabannes.** (Comptes Rendus, 160. pp. 62–68, Jan. 11, 1915.)—The author by a photographic photometry has tested the Rayleigh formula for light scattering. Thus if Q is the ratio of the lateral scattering in air at atmospheric pressure to that of the source, the preliminary experiments give the following :—

λ	Q
0·303 μ	$3{\cdot}65 \times 10^{-8}$
0·334 μ	$2{\cdot}70 \times 10^{-8}$

If we suppose the number of molecules per cm.^{3} unknown, the above data would give a value in the neighbourhood of $2{\cdot}5 \times 10^{19}$. And Avogadro's constant would be of the order 55×10^{22}. E. H. B.

432. *Total Reflection and Poynting's Theorem.* **A. Wiegrefe.** (Ann. d. Physik, 45. 4. pp. 465–480, Oct. 1, 1914.)—Mathematical discussion of ideal cases. [See Abs. 897 (1910).] E. H. B.

433. *Scattering of Light in a Gaseous Medium.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. pp. 1–29, Jan., 1914.)—Mathematical treatment on the electron theory. E. H. B.

434. *Molecular Theory of the Reflection of Light.* **L. Natanson.** (Acad. Sci. Cracovie, Bull. pp. 335–352, June, 1914.)—The analytical method employed in a previous paper [preceding Abs.] is here applied to the problem of reflection from the surface of transparent or semi-transparent bodies. L. H. W.

435. *Polarisation of the Light diffracted at a Metallic Screen.* **R. Schachenmeier.** (Ann. d. Physik, 45. 7. pp. 1109–1120, Nov. 17, 1914.)—Mathematical. E. H. B.

436. *Broadening of Series Lines.* **G. Wendt.** (Ann. d. Physik, 45. 8. pp. 1257–1264, Dec. 3, 1914.)—The series lines of Hg, Sr, and Na were investigated under varying conditions of current density and of pressure and the following results obtained :—(1) Diffuse series lines are more broadened than sharp series lines, and these more than principal series lines, corresponding members being compared. (2) Within the same series the broadening increases with the number of the member. (3) Within the same member (doublet, triplet) the broadening decreases as the number of the components increases. (4) The broadening of Hg lines runs parallel with their electrical effect, as might be expected if the former is due to the increase of ionic density with current density and pressure. J. M.

437. *Intensity Ratio of the Long- and Short-wave Electric Components of the Series Lines of Hydrogen.* **H. Lunelund.** (Ann. d. Physik, 45. 4. pp. 517–528 Oct. 1, 1914.)—A discharge tube was used of the type employed by Stark in his observations on the effect of an electric field on the canal-ray spectrum. The results of the research were as follows :—The intensity ratio of the outer long- and short-wave electric components of the same number is for the series lines of hydrogen considerably greater than unity ; it was found in some cases to be from 2 to 2·7. This intensity ratio is dependent on the kathode-fall, and therefore on the velocity of the canal-rays, and certainly increases with increasing velocity. This law also holds in the case of the *p*- and of the *s*- components. Within the series the intensity ratio seems to increase with increasing number, excepting the *s*- components of Hg. The intensity ratio of a long- and a short-wave component of the same number decreases both for the *p*- and the *s*- components towards the middle and therefore with decreased component number, and as the frequency of the undecomposed line is approached the ratio approaches the value unity.

A. W.

438. *Emission of Light by Metallic Vapours in the Glow Discharge.* **L. Janicki** and **R. Seeliger.** (Ann. d. Physik, 44. 8. pp. 1151–1168, Aug. 4, 1914. Communication from the Physikal-Techn. Reichsanstalt.)—A simple method is given by which the spectrum of a metallic vapour can be investigated either in the negative glow or in the positive column. The metal to be dealt with is used as electrode, when its vapour can be obtained and the spectrum observed. Numerous metals, including Zn, Mg, Pb, Al, Sn, Ag, have been employed, and it is found that there is a marked similarity in the emitted spectra, on the one hand between the spark spectrum and that from the negative glow, and on the other hand between the arc spectrum and that of the positive column. In particular, the pure spark lines occur only in the negative glow, the arc lines only, or with greater intensity, in the positive column. The metalloid silicium behaves in exactly the same way as the metals investigated. With tellurium no such analogy between the spark and arc spectra and those of the negative glow and the positive column exists. This is the single exception in all the substances dealt with. Research with zinc and cadmium in externally-heated discharge tubes with internal electrodes gave results in agreement with those obtained by the other method.

A. W

439. *Band Spectrum of Boron Nitride.* **W. Jevons.** (Roy. Soc., Proc. 91. pp. 120–134, Jan. 1, 1915.)—A continuation of the spectroscopic investigations in connection with the active modification of nitrogen [Abs. 1823 (1913)]. By introducing the vapour of BCl_3 into active nitrogen a very pale blue-green glow is obtained of which the spectrum consists of the three boron lines λλ3451·50, 2497·83 and 2496·89 Å.U. and a new system of bands together with bands of impurities, nitrogen and cyanogen. The new bands are quite distinct from the headless wavy bands attributed to the boron oxide spectrum. They extend from the red right to the limits of a quartz spectrograph and degrade throughout to the less refrangible side. Two principal systems are discernible: one, complex, situated in the ultra-violet; the other a simple double-headed series confined to the visible regions. In the latter series the component heads (A_1 and B_1) of the bands have a constant frequency separation of 124 units. Moreover, each head is a doublet (A_1 and A_2) with a separation of 13 units. The heads conform to a Deslandres equation of the form: $n = A + B(m + \mu)^2 + C(p + \pi)^2$, where $A = -12203$, $B = -10{\cdot}20$, $C = 11{\cdot}85$, $\mu = 0{\cdot}04$ and $\pi = 0{\cdot}18$, while m and p take successive integral values for consecutive values of n, and are of the magnitude 61 and 79 respectively. The more numerous single heads of the more refrangible system correspond to a similar formula, but the constant A now becomes + 8291. The ranges of m and p are nearly the same in the two systems. Besides these two principal systems, α and β respectively, traces of two subsidiary systems β_1 and β_2 can be recognised. The bands are obtained when $(CH_3)_3BO_3$ replaces the chloride. They are, however, not found in the Bunsen flame with the methyl ester or in the non-disruptive boron spark spectrum in nitrogen. In the arc spectrum of the oxide in air, where

nitride is known to be formed, the strongest head of the α series is noticeable, but the headless oxide bands present mask the other heads. The source of the new bands is therefore the nitride, so that boron is analogous to carbon and silicon in developing a nitride spectrum in the nitrogen afterglow.

C. S. G.

440. *Absorption Spectra of Organic Substances and the Electron Theory.* **N. P. K. J. O'N. McClelland.** (Phil. Mag. 29. pp. 192–206, Jan. 1915.)—A mathematical treatment of the absorption of light in terms of the electronic constitution of atoms. Valency electrons are supposed to move in circular orbits round a central nucleus and when the valency becomes saturated the corresponding electron is held to be withdrawn out of its orbit, probably into one of greater radius about the line joining the nuclei, and of a period much greater than in the original state. The free electrons respond to light and have a mutual influence on each other, so that the problem consists in compounding vibrations by means of the mutual induction method. Drude has dealt with the case of one vibration centre and the treatment is here extended to the symmetrical cases of two, three, and four centres and applied to the cases of benzene and its simpler derivatives. C. S. G.

441. *Canal-ray Spectra.* **J. Stark** and **R. Künzer.** (Ann. d. Physik, 45. 1. pp. 29–74, Aug. 14, 1914.)—A continuation of previous work [Abs. 1960 (1913)] dealing with the lines in the canal-ray spectra of aluminium, sulphur, chlorine, iodine, and nitrogen, due to singly- and multiply-charged ions. The results may be summarised as follows :—(i) *Aluminium.*—The doublets of the first and second subordinate series have the same carriers, namely, the positive singly-charged atomions. For the ultra-violet spark lines the intensity of the displaced line, in comparison with the effect for the arc lines, is very much greater than that of the stationary line ; they have the same positive doubly- or trebly-charged atomions as carriers. In the arc spectrum, besides the known doublets, other doublets have been found with smaller frequency-difference ; in the canal-rays they behave much more like spark lines than the known doublets, and hence have probably the same positive singly-charged atomions as carriers. (ii) *Sulphur.*—In the positive column, with small to moderate current density, a line (arc) spectrum is emitted. This consists of two groups of lines ; one (the first arc spectrum) comprises the lines arranged in series by Runge and Paschen, the other (the second arc spectrum) with not many lines, includes λλ4157·9, 4152·9, 4151·0. With larger current-density in the oscillatory spark the known sulphur line-spectrum (spark spectrum) appears ; this is likewise composed of two groups of lines. The sharp spark lines, relatively to the other group of diffuse lines, remain sharp with increased current-density, while the diffuse lines are unmistakably broadened. In pure sulphur-vapour the scattering of the rays and the related diminution of their velocity is very marked. With the same kathode-fall the velocity of the sulphur rays in pure sulphur-vapour is therefore much smaller than in helium, where the scattering is small. The principal series triplet of the first arc spectrum λλ4696·488, 4695·690, 4694·357, with a 7000-volt kathode-fall and strong scattering (nearly pure sulphur-vapour and small velocity) shows near a large stationary intensity a small, but distinguishable, displaced intensity. With increasing velocity of the rays, consequently with less scattering (sulphur rays in He), the stationary lines of the triplet increase the more. With the lines of the second arc spectrum, however, when the scattering is small the displaced intensity is very much greater than the stationary intensity. The sharp and diffuse spark lines with strong scattering appear, both in the displaced and stationary lines, very weak compared to the arc lines. The four kinds of lines probably arise as follows: The first arc spectrum has the singly-charged S_2 molecule-ion as carrier. The lines of the second arc spectrum are due to the positive singly-charged S-atomion, the sharp spark lines to the positive doubly-charged atomion, and the diffuse to the positive trebly-charged atomion. (iii) *Chlorine.*—This has both an arc and a spark spectrum. In the latter, two principal groups of lines, sharp and diffuse, can be distinguished. The chlorine arc lines behave as if due to positive singly-charged atomions. The sharp spark lines are due to the positive doubly-charged atomion; the diffuse lines, at least in part, are emitted by the positive trebly-charged atomion. (iv) *Iodine.*—This presented difficulty and was not investigated fully. (v) *Nitrogen.*—Both arc and spark spectra were observed. Three groups of lines were found: sharp and diffuse spark lines, and a third group which has not up to the present been observed in canal-ray spectra. The arc lines behave like single-valued lines. The displaced intensity in the sharp and diffuse spark lines is, for large velocities, considerable; the distribution curve shows at least three velocity intervals. It is probable that the sharp spark lines are due to positive doubly-charged atomions, the diffuse lines being emitted by the positive trebly-charged atomions. A. W.

442. *Wave-lengths of Spectra of Nitrogen and Oxygen.* **J. S. Clark.** (Astrophys. J. 40. pp. 332–336, Oct., 1914.)—The investigation was undertaken to provide reliable wave-lengths of the chief lines in the spectra of nitrogen and oxygen, important elements in stellar spectra, so that some of the uncertainties in radial-velocity results might possibly be eliminated. It was found that suitably sharp lines could be produced when a highly condensed discharge was passed through dry air at low pressure in a capillary vacuum tube, and the spectra were photographed in the third-order spectrum of a 10-ft. grating spectrograph, mounted on the plan devised by Eagle [Abs. 1102 (1910)], giving a dispersion of 1·7 Å. per mm. The iron arc was used for comparison, and the wave-lengths are given both on the International and the Rowland system. C. P. B.

443. *Constant Differences in Line Spectra.* **E. Paulson.** (Astrophys. J. 40. pp. 298–310, Oct., 1914. Ann. d. Physik, 45. 1. pp. 147–175, Aug. 14, 1914.)—Tables are given showing the constant differences of wave frequencies for special lines of Cl, Mn, Ni, Mo, Pd, La, Sm, Eu, Ce, Xe, I, Dy, Er, Tm, and Lu. By application of the results of the Zeeman-effect on these spectra it may be possible to detect the presence of related series. C. P. B.

444. "*Grundspectra*" *of Alkali Metals.* **E. H. Nelthorpe.** (Astrophys. J. 41. pp. 16–27, Jan., 1915.)—Goldstein's supposed new spectra of alkali metals announced in 1908 were subsequently shown (in the case of potassium) by Schillinger to be characteristic of the spark between metallic potassium electrodes in an atmosphere of hydrogen. The importance of the method, however, lay in the possible separation of the special spark lines from the arc lines of the substances [Abs. 1236 (1910)]. Special photographs of the spectra of K, Rb, Sr, Ca, and Ba have been made to investigate further the *Grundspectra* lines, and the conclusion is that these are essentially the lines specially developed in the ordinary spark spectrum: with K and Rb the spectra consist entirely of the enhanced lines, but with the metals of the calcium group the last traces of the arc spectrum have not been entirely

removed. It is to be noted that the arc spectra of K and Rb contain no spark lines, while in the arc spectra of the calcium group the spark lines appear very strongly. C. P. B.

445. *Blue Spectrum of Argon.* **E. Paulson.** (Astrophys. J. 41. pp. 75–77, Jan., 1915.)—Rydberg has shown that most of the lines in the so-called *red* spectrum of argon between λ2967 and λ4702 may be arranged in quadruplets. The author examines all the lines recorded in the so-called *blue* spectrum o argon between λ2762 and λ5145, and although a group of four apparently related lines was found, there does not appear to be any relation between this group and the quadruplets in the red spectrum. C. P. B.

446. *Spectrum of Yttrium.* **E. Paulson.** (Astrophys. J. 41. pp. 72–75, Jan., 1915.)—Examination of the wave-lengths of the lines in the spectrum of yttrium from λ2227 to λ6701 shows several interesting sets of constant wave-number differences. These are tabulated with the object of facilitating investigations regarding series relationships among the lines. C. P. B.

447. *Secondary Wave-length Standards in Red Part of Iron Spectrum.* **P. Eversheim.** (Ann. d. Physik, 45. 3. pp. 454–456, Sept. 15, 1914.)—Gives a table of 17 secondary wave-length standards in the iron spectrum ranging from λ6003·039 to λ7445·800. The values obtained by Fabry and Buisson for 7 of the lines, and by Burns for 14 lines, are given for comparison. [See also Abs. 255 (1910) and 492 (1912).] A. W.

448. *Line Spectra.* **S. Popow.** (Ann. d. Physik, 45. 1. pp. 147–175, Aug. 14, 1914.)—The line spectra of Ca, Sr, Ba, Y, Sc, Al, and Si were investigated. The results are discussed in relation to Ritz's combination principle. A. W.

449. *Electrical and Optical Resonance.* **K. F. Lindman.** (Ann. d. Physik, 45. 4. pp. 580–622, Oct. 1, 1914.)—Describes research on the resonating and reflecting powers of various types of resonator. [See also Abs. 470 and 1348 (1903).] A. W.

450. *Universality of the Zeeman-effect with respect to the Stark-effect in Canal Rays.* **H. du Bois.** (K. Akad. Amsterdam, Proc. 17. pp. 873–877, Jan. 28, 1915.)—Plates of ruby were obtained about 8 mm. thick, one cut perpendicular and one parallel to the crystal axis. Specially mounted these were subjected to fields of about 667 e.s. units. The absorption lines, especially the two strongest lines R_2 and R_1 in the red, λ6918 and λ6932, were observed in the first order of a concave grating. No influence of the field could be detected. In any case the displacement or separation, if such exists, is less than one-hundredth of the magnetic longitudinal effect in a field of 50 kilogauss. Negative results were also obtained with neodymium nitrate hexhydrate, both in crystal form and in solution. [See also Abs. 1534 (1914).] A. W.

451. *Abnormal Rotation in Zeeman Triplets and Negative Faraday-effect.* **W. Voigt.** (Ann. d. Physik, 45. 3. pp. 457–462, Sept. 15, 1914.)—A discussion based on the coupling theory. It is shown that an abnormal triplet would lead to a rotation of the plane of polarisation in the negative direction. But such a direction of rotation appears also in many cases; it always appears when the intensity centre of all the components lies, with positive rotation, on the side of the smaller frequency, or with negative rotation on the side of the larger frequency. A. W.

452. *Zeeman-effect in Neighbouring Spectral Lines.* **H. du Bois** and **G. J. Elias.** (Ann. d. Physik, 45. 8. pp. 1160–1164, Dec. 8, 1914.)—A list is given of 16 principal types of the Zeeman-effect observed with crystalline substances in magnetic fields at low temperatures; in addition all sorts of combinations of these principal types have been observed. Some of these are discussed, special reference being made to the spectra of the rare earths. A. W.

453. *Efficiency in Excitation of Phosphorescence by Canal Rays.* **E. Rüchardt.** (Ann. d. Physik, 45. 7. pp. 1063–1088, Nov. 17, 1914. Abstract of Dissertation, Würzburg.)—The method adopted is to obtain by means of a thermo-element and galvanometer an absolute measure of the energy of the phosphorescence emitted, at the same time as obtaining the energy of the canal rays which impinge on the phosphorescent screen. The apparatus and experimental methods are described in detail. The green phosphorescent $SrSBiNa_2SO_4$ is used in preference to zinc sulphide. The absolute graduation of the thermo-element, the graduation of the photometer wedge, the determination of the power of reflection of white screens used for comparison of light, the radiation of the phosphorescent surface, and calculations based on the experimental results, are among the points dealt with. It is shown that the energy emitted by a scintillation must be $8{\cdot}2 \times 10^{-8}$ erg, when the distance of the eyes is 8 cm. and diam. of pupil 8 mm., in order to produce a perceptible light-impression. It is found that for rapid kathode rays about a 10 times larger fraction of their energy is transformed into phosphorescent light than for canal rays. A. E. G.

454. *Photoelectric Photometry of Phosphorescence Phenomena.* **A. Pospielow.** (Ann. d. Physik, 45. 7. pp. 1039–1062, Nov. 17, 1914.)—The author uses the photoelectric method to study the phosphorescence excited in a number of Lenard's "phosphores" by kathode rays in discharge tubes and by rays from the mercury-arc lamp, the decay of the phosphorescence being investigated at room temperature and at the temperature of liquid air. In its first stages this decay is a very complicated process depending on a number of factors, such as metal-content, nature and intensity of excitation, etc. Since certain of these conditions cannot be kept absolutely constant, constant decay curves are unattainable. With short excitation the initial intensity is often greater than with the maximal excitation, but it diminishes more rapidly. With kathodic excitation the initial intensity of the phosphorescence is far greater than with excitation by light-rays, while its decay is more complicated and therefore requires the superposition of a greater number of exponential functions for its expression. With the various bands the decay in the first few seconds takes place as if the phosphore were a mixture of several kinds of phosphorescing centres of varying length of life. Kathode rays appear to excite short-lived centres in greater numbers than do light-rays. With the phosphores, CaCuLi and CaPbK, the light-energy of an atom of the active metal, expressed in quantums, corresponds with its max. valency, the number of electrons separated from each atom of the active metal being equal to the valency of the metal. A representation is given of the phosphorescing molecule, consisting of calcium, copper, and sulphur, suggestions being made with reference to the physical significance of the magnitudes in the formula expressing the decay of the phosphorescence. T. H. P.

455. *Radium-like X-rays.* **F. Dessauer.** (Phys. Zeitschr. 15. pp. 739–741, July 8, 1914.)—On medical grounds it is of great importance to be able to obtain Röntgen radiation which possesses the penetrating power of γ-rays. The present research has been carried out with this aim in view. Determinations of the absolute absorption coefficients (μ/ρ) of γ-rays from radium and mesothorium preparations show clearly the complex nature of the γ-radiation. Rutherford [Abs. 1675 (1913)] gives the following values of the absorption coefficients: $\mu = 0{\cdot}5$ cm.$^{-1}$ for γ-rays from RaB and $\mu = 0{\cdot}115$ cm.$^{-1}$ for γ-rays from RaC. The absorption coefficients of ordinary X-rays lie between the limits 8 and 4 cm.$^{-1}$, whilst for hard X-rays the limits are 4 and 2 cm.$^{-1}$. Generally speaking the absorption coefficients of X-rays are 10 to 80 times greater than for γ-rays. According to numerous observations, 1 cm. of flesh absorbs from 30 to 90 % of X-rays, but only from 4 to 8 % of γ-rays. Methods are now described for producing X-rays of absorption coefficient less than 0·1 cm.$^{-1}$; 1 cm. of flesh only absorbing from 5 to 6 % of these rays. Determinations have been made of the absorption coefficients of the complex beam of X-rays from an extremely hard bulb, the absorption coefficients being measured after the rays have passed through various thicknesses of aluminium. A series of such results is included in the following table—

COMPLEX NATURE OF γ-RAYS FROM A RÖNTGEN TUBE.

"Hardness" of the Radiation, in Benoist Units.	Absorption Coefficient in Al, μ/ρ.	Absorbing Screen, cm. Al.	Intensity in Percentage of Initial Intensity.
9·5	2·17	0	100·0
10·6	0·557	0·3	17·2
11·5	0·473	0·6	11·1
11·8	0·468	0·9	7·46
12·0	0·511	1·2	5·10
12·3	0·538	1·5	3·38
12·45	0·285	1·8	2·18
12·55	0·499	2·1	1·46
12·65	0·373	2·4	0·98
12·8	0·239	2·7	0·74
12·9	0·38	3·0	0·59
12·9	0·38	3·3	0·44
13·0	0·31	3·6	0·32
13·0	0·34	3·9	0·25
13·0	0·28	4·2	0·19

A curve expressing the intensity of radiation as a function of the absorption coefficient shows clearly that in addition to the ordinary type of X-rays there is also present another type of penetrating power equal to that of γ-rays. From a consideration of the results just mentioned the author calculates the velocity of kathode rays necessary to produce X-rays of this great penetrating power, and discusses the various technical methods of obtaining kathode rays of this velocity.
A. B. W.

456. *X-ray Spectroscope.* **H. Rohmann.** (Phys. Zeitschr. 15. pp. 510–512, May 15, 1914.)—W. H. and W. L. Bragg have shown that the radiation emitted from a Röntgen tube contains a number of sharp, intense lines in addition to a continuous spectrum [see Abs. 1330 (1913)]. When the X-rays are reflected from a crystal the following relation has been shown to hold: $n\lambda = 2d \sin \alpha \ldots (1)$; where n is an integer, d the distance apart of two molecular layers, α the angle between the incident or reflected beam and the molecular

layer, and λ is the wave-length of the incident radiation. De Broglie, using the relation (1), has shown that a complex beam of X-rays can be analysed into a line spectrum by using a slowly rotating plate of crystal [Abs. 243, 244, 675 (1914)]. Of course, the nature of the spectrum depends on the material of the anti-kathode.

The author describes an arrangement whereby a beam of X-rays (parallel or otherwise) is allowed to follow on a cylindrical crystal surface (a curved sheet of mica). Consequently different parts of the beam make different angles with the surface and a line spectrum is obtained without rotation of the crystal. The following dimensions for obtaining a sharp line spectrum are given :—Width of slit, 0·7 mm.; distance of slit from centre of curvature of reflecting surface, about 20 cm.; radius of curvature, $r = 5$ cm.; the photographic plate is placed tangential to the curved surface of the cylinder and at right angles to the incident beam of X-rays. With a Pt anti-kathode 2 groups of 4 lines are obtained representing two "orders." The chief characteristics of the spectra are essentially similar to those obtained by de Broglie. A. B. W.

457. *Fluctuations in the Emission of α-Rays from Radio-active Solutions.* **T. Svedberg.** (Phys. Zeitschr. 15. pp. 512–516, May 15, 1914.)—It has been shown in a previous paper [Abs. 730 (1913)] that the case of emission of α-rays from a radio-active solution differs from that when the radio-active substance is in the solid form, in that the fluctuations in the emission of α-particles are greater in the former than in the latter case. The spontaneous fluctuation in concentration of solutions has been previously worked out on the kinetic theory of molecules. In this connection E. v. Schweidler [Abs. 1218 (1913)] has put forward the view that from a consideration of the theoretical frequency-distribution of the disintegrating atoms no difference between a radio-active solution and a radio-active solid preparation is to be expected.

In the present paper the author discusses this question mathematically and concludes that v. Schweidler's view is correct. Radium chloride and polonium chloride in the solid condition and in solution have been used in the experiments to test the theory, the results obtained giving full support to the views advanced in the theoretical discussion. A. B. W.

458. *Magnetic Spectrum of β-Rays from Uranium X.* **O. v. Baeyer, O. Hahn,** and **L. Meitner.** (Phys. Zeitschr. 15. pp. 649–650, July 1, 1914.)—In previous papers the β-ray spectra of all the radio-active substances, with the exception of actinium, mesothorium 1, and uranium X, have been described. The β-rays from UrX are now dealt with. It is well known that UrX emits a very small amount of γ-radiation in comparison with its β-radiation. If the γ-rays from RaC and UrX are compared it is seen that with equally penetrating β-rays the γ-radiation of UrX is only 1 % of that of RaC. In the case of RaE also the γ-radiation is very weak in comparison with the β-radiation. From observations on the β-rays of this substance it has been found that, instead of a line spectrum, a continuous magnetic spectrum is obtained. Rutherford cites this as confirmation of his view that there is a definite connection between the origin of γ-rays with the emission of a magnetic line-spectrum of β-rays. Consequently, from analogy with RaE, we should expect, on account of the feeble intensity of its γ-radiation, that the spectrum of the β-rays from UrX would be continuous. These observations are completely borne out by the results of experiments—a continuous band crossed by several sharp lines being obtained. A. B. W.

459. *Distribution of Energy in Different Types of γ-Rays.* **J. Szmidt.** (Phil. Mag. 28. pp. 527–539, Oct., 1914.)—The investigation consists of an attempt to obtain the distribution of energy in the γ-rays emitted by RaB, RaC, and RaD, the method employed being a comparison of the total number of ions each type of ray produces in air or other gas. The following assumptions have been made: (1) The same proportion of energy of the different γ-rays is spent in ionisation, either direct or indirect; (2) the energy required to produce an ion is the same for γ-rays of different penetrating power. The first part of the paper contains a description of experiments carried out to test the correctness of the second assumption. In this connection two types of γ-rays are dealt with—namely, the soft γ-rays from RaD ($\mu = 45$ cm.$^{-1}$ Al) and the hard rays of RaC ($\mu = 0{\cdot}115$ cm.$^{-1}$ Al). The absorption of γ-rays by various gases is first considered, the coefficients of absorption being given in the following table:—

ABSORPTION OF SOFT γ-RAYS FROM RaD.

	μ at 18° in cm.$^{-1}$ Al.	μ at 0°.	μ/ρ.
Air	0·00382	0·00407	3·15
CO_2	0·00643	0·00674	3·42
H_2S	0·0318	0·0338	22·0
SO_2	0·0381	0·0406	13·9

The above values for γ-rays are of the same order of magnitude as for X-rays of corresponding penetrating power.

In dealing with the hard γ-rays from RaC, liquid SO_2 was used as absorber, and from the results the mass absorption coefficient deduced. The value of μ obtained for gaseous SO_2 is in good agreement with Chadwick's value 0·000060.

Using soft γ-rays, in the case of CO_2 and SO_2 it was shown that the ionisation is approximately proportional to the absorption; consequently the relative ionisations do not differ much from unity. Similar experiments with hard γ-rays showed no essential difference, *i.e.* in this case also the ionisation is proportional to the absorption.

The second portion of the paper deals with the main question—the relative energy of different types of γ-rays. It is shown that the hard γ-rays from RaD possess from 17 to 35 % of the total γ-energy belonging to RaD. The distribution of energy in RaB + RaC in equilibrium is as 1 : 45 : 639 respectively for the soft rays from RaB, the hard rays from RaB, and the rays from RaC. A. B. W.

460. *Adsorption of UrX₁ in the Presence of other Substances.* **H. Freundlich, W. Neumann, and H. Kaempfer.** (Phys. Zeitschr. 15. pp. 537–542, May 15, 1914.)—The existence of certain inseparable radio-active elements is well known. These groups of inseparable or, as Soddy calls them, "isotopic" elements occupy in the periodic classification the places usually filled by a single element. Ritzel [Abs. 460 (1910)], investigating the adsorption of UrX_1 by animal charcoal, found that the strong power of adsorption was completely removed in the presence of small quantities of thorium salts (isotopic with UrX_1), whilst a substance like aluminium sulphate had no influence whatever on the adsorption. The present experiments confirm the observations made by Ritzel. Thus it is shown that the action takes place even with extremely small quantities; for example, a proportion of 0·0004 millimol $Th(NO_3)_4$ per litre (*i.e.* 0·2 mgm. per litre) increases the activity of the solution after the adsorption to the extent of 20 %. The action is not limited to thorium alone, or even to the radio-elements, but is produced by a large number of substances, such as zirconium salts, benzoic acid, strychnine nitrate, etc. Consequently the phenomenon cannot be explained on the grounds that Th replaces the UrX_1 which is isotopic with it, at the surface of the charcoal. Probably the action takes place in a displacement of UrX_1 by any other substance which is more strongly adsorbed; thus it follows that the UrX_1 can also be displaced from the charcoal by subsequent addition of thorium nitrate; further, the Cu-ion can also be replaced by Th at the charcoal surface in a similar manner, depending in this case also on the concentration of the thorium nitrate. From observations of this character the author shows that it is incorrect to look upon isotopic elements as chemically identical. On account of the inseparability of these substances by ordinary chemical reactions it is suggested that the phenomenon is connected in some way with the "chemical mimicry" observed in the case of the rare earths—one element impressing its own behaviour on neighbouring elements.

Ritzel [*loc. cit.*] has shown that the power of adsorption of UrX_1 by charcoal is diminished in the presence of ThEm. The author shows that this effect disappears if the emanation is previously filtered through a plug of cotton-wool. A. B. W.

461. *Magnetic Deflection of Recoil Stream from Radium A.* **H. P. Walmsley** and **W. Makower.** (Phil. Mag. 29. pp. 253-258, Feb., 1915.)—The deflections in an electric and a magnetic field of the recoil stream of RaB have been previously studied by Russ and Makower, and by Makower and Evans [Abs. 239 (1911)]. It was of importance to repeat these experiments with greater accuracy to determine the atomic mass of RaB, and to find out how nearly the velocity of the recoiling atoms is in agreement with that calculated from the law of conservation of momentum. The present paper describes a series of magnetic experiments, the investigation of the electric deflection being postponed. Since the recoil atoms carry only one elementary charge, whilst the α-particles carry two, it follows at once that when they both pass through the same magnetic field the radius of curvature of the α-stream should be exactly double that of the recoil stream. The apparatus, comprising the "line-source" of RaA, the slit and the photographic plate, was of the type usually employed in experiments of this nature. A uniform field of 15,000 gauss over an area 16 cm. × 5 cm. was maintained. In order to ensure a high efficiency of recoil the wire was made active with RaA in such a way that it could be removed from the emanation without drawing it through mercury. As a result of a large number of observations a mean of 0·5009 was obtained for the ratio of the deflection of the recoil atoms to that of the α-particles—thus proving, as we should expect from the law of conservation of momentum, that the radius of curvature of the recoil stream in a magnetic field is accurately twice that of the α-rays. A. B. W.

462. *Velocity of α-Particles from Radium A.* **N. Tunstall** and **W. Makower.** (Phil. Mag. 29. pp. 259-260, Feb., 1915.)—Rutherford and Robinson [Abs. 310 (1915)] have recently given the very accurate value $1{\cdot}922 \times 10^9$ cm. per sec., as the velocity of the α-particles from RaC. From this value the velocities of the α-particles from other radio-active

substances have been calculated by Geiger's formula, $v^3 = kR$, which gives the relation between the velocity v of an α-particle and its range R in air. Using the apparatus of Walmsley and Makower [preceding Abs.] the authors have made a direct comparison between the velocity of the α-particles from RaA with that of the α-particles from RaC. Magnetic deflections (using fields up to 14,000 gauss) only were measured, and a mean value of 0·8792 given for the ratio of the radii of curvature of the paths of the two sets of α-particles. Taking the velocity of the α-particles from RaC as $1{\cdot}922 \times 10^9$ cm. per sec., this gives for the velocity of α-rays from RaA the value $1{\cdot}690 \times 10^9$ cm. per sec., which is in close agreement with the value $1{\cdot}698 \times 10^9$ cm. per sec., calculated by Geiger's formula. A. B. W.

463. *Volatility of Thorium D.* **A. B. Wood.** (Phil. Mag. 28. pp. 808–818, Dec., 1914.)—The chief aim of this investigation was to provide more direct information on the process of radio-active recoil by a detailed study of ThD, collected under a large variety of conditions. The temperatures of volatilisation of this substance, untreated or dissolved in various mineral acids, were first determined, and a comparison was made between the ThD recoiling from several of its compounds. Results obtained give further support to the views of Schrader, Russell, and Barratt and Wood [Abs. 1761, 1762 (1912), 188 (1915)] on the formation of definite chemical compounds of the active deposits of radio-active substances: temperature of volatilisation of ThD untreated with acid, 520° C.; treated with HNO_3, 520° C.; treated with HCl, 270° C. The author shows that ThD recoils in the *atomic* form, whatever the form of the parent ThC (free, or combined with acids). The paper is concluded by a determination of the relative β-activities of ThC and ThD. These two products are completely separated by a volatilisation method and from the subsequent growth of β-activity the ratio of the β-activities of the separate products is calculated. A. B. W.

464. *Radium Uranium Ratio in Carnotites.* **S. C. Lind** and **C. F. Whittemore.** (Am. Chem. Soc., J. 36. pp. 2066–2082, Oct., 1914.)—Many observers have noticed considerable variations from the constancy of the ratio of Ra to Ur in old Ur-bearing rocks, and several explanations of these divergencies have been advanced from time to time. The explanation of the high ratio appeared to present much more formidable difficulties than the low ones. Mlle. Gleditsch favoured the view that either ionium or some other unknown member between Ur and Ra has a much longer period than previously supposed, necessitating a greater lapse of time for equilibrium to be attained. According to this view, all the Ur minerals would be slowly advancing to an equilibrium quantity of Ra higher than that in most pitchblendes. Recent researches by Hermann and Marckwald on a large number of pitchblendes from different localities showed the constancy to be within 0·4 %, measurements being made both by emanation and γ-ray methods.

The increasing importance of carnotite as one of the chief sources of Ra made it appear desirable to investigate the Ra : Ur ratio in a large number of samples of this mineral. All grades of carnotite from 1·5 to 33 % of U_3O_8 have been included. In the determination the emanation method has been exclusively employed, and a comparison of results of the different methods of "de-emanating" carnotites is given. The Ur was in all cases estimated gravimetrically. On inspecting the tabulated results shown in the paper, it is clear that the Ra : Ur ratio of carnotite is identical with that of pitchblende ($3{\cdot}33 \times 10^{-7}$) in all large quantities of well-sampled ore. The *low* and *high* ratios occur only in cases of small samples of ore and are apparently due to local transposition of Ra within the ore bed, resulting in differences which are completely equalised on sampling sufficient quantities of ore. The "emanating power" of carnotite is high and varies from 16 % to 50 %.

A. B. W.

465. *Radio-active Products in the Atmosphere.* **S. Satô.** (Sci. Reports, Tôhoku Univ., Sendai, 2. No. 4, pp. 171–174, 1913.)—Determinations of the relative amounts of radium and thorium emanations in the atmosphere have been made by Eve and by Satterly [Abs. 417, 1964 (1908)] by *direct* methods, (*a*) by absorbing the emanation in coconut charcoal, or (*b*) by condensing it at the temperature of liquid air. The present paper gives an account of an *indirect* method, previously used by Kinoshita, Ono, and others, in which the radio-active matter is collected from the atmosphere on a negatively charged wire stretched horizontally above the ground. The wire was kept at a potential of —10,000 volts for 3 hours, and its activity measured in a previously calibrated electrometer. From the curves of decay of the active deposit it was shown that the emanations were from Ra and Th only, in the ratio of 1 to 15,000. The following table gives a comparison of the author's results with those of other observers in different localities :—

Observer.	Amount of RaEm in Curies per m.^{3}.	Calculated Value of Number of Atoms of RaEm in 1 cm.^{3} of Atmosphere.	Locality.
Eve	60×10^{-12}	1·0	Montreal
Ashman	89×10^{-12}	1·5	Chicago
Satterly	105×10^{-12}	1·8	Cambridge
Satô	—	1·5	Tôhoku

A. B. W.

HEAT.

466. *Measurements of Specific Heats of Solids with Note on Molecular Weight Determination.* **R. Ewald.** (Ann. d. Physik, 44. 8. pp. 1213–1237, Aug. 4, 1914.)—A calorimeter similar in principle to that used by Nernst and others for specific-heat determinations at low temperatures [Abs. 1698 and 1702 (1911)] has been employed for the determination of the mean specific heats of a large number of elements and compounds for the temperature-ranges − 190° to − 78°, − 78° to 0°, and 0° to 55° C. The calorimeter consisted of a copper block, into a hole in which could be inserted a small silver bucket containing the specimen. The copper block was placed in a Dewar vessel surrounded with either liquid air or ice, and the silver vessel and contents, after having been brought to the requisite initial temperature, was transferred to the block, the resulting change of temperature being measured by means of thermo-couples. Several of the ammonium salts employed showed anomalous values of the specific heats between − 78° and 0° C., the values being greater than those for the higher temperature-range. No anomaly could be found in the thermal expansion. The cause of the anomaly must thus be intramolecular and should be accompanied by changes in the dielectric constant. Experiments to test this are being undertaken. The Nernst-Lindemann and the Debye formulæ for the atomic heats of solid bodies afford a criterion for determining whether a molecule of an element contains one or more atoms. In this way the author concludes that Cd, Sn, Th, Mg, and Fe are monatomic, and P, As, Bi, and Sb are polyatomic.

F. J. H.

467. *Specific Heats at Low Temperatures.* **W. H. Keesom** and **H. K. Onnes.** (K. Akad. Amsterdam, Proc. 17. pp. 894–914, Jan. 28, 1915. Comm. No. 143 from the Phys. Lab., Leiden.)—The paper describes the determination of the specific heats of lead between 14° and 80° K. and of copper between 15° and 22° K. The method used is similar to that developed by Eucken and Nernst [Abs. 1714 (1909), 1702 (1911)]. The specimen in the form of a hollow cylinder contained a copper core of three concentric cylinders; the inner two of these were wound with constantan and gold wires respectively, the first to serve as the heating coil and the second as the thermometer. The whole was suspended by thin silver leads in a vessel highly evacuated by means of charcoal in liquid hydrogen, the vessel itself being placed in a cryostat. The accuracy of the measurements was increased by the fact that use was made of the recent work of Onnes and Holst [Abs. 81 (1915)] upon the measurement of very low temperatures. For the purpose of testing Debye's theory of specific heat the values of the specific heats at constant volume were calculated by means of the relation obtained by Nernst—namely, $C_p - C_v = 3{\cdot}2 \times 10^{-5} T C_p^2$. In agreement with Eucken and Schwers [Abs. 1844 (1913)] the authors find that the observations for lead show in general a good concordance with Debye's formula over the whole range if $\theta = 88$ is taken as the characteristic temperature. The concordance is not complete, however, systematic deviations as large as 4% being manifest at about 30° K. which are larger than the probable experimental errors; possible reasons for these deviations are indicated. Thirring's modification of the theory of Born and Kármán [Abs. 266, 904, 905 (1914)] is also considered, but the deviation from the results obtained by Debye's theory given by Thirring's formula is found to be in the opposite direction to that found experimentally. The results obtained for copper are shown to follow Debye's T^3-law to within 2 %. F. J. H.

468. *Ratio of Specific Heats at Various Pressures.* **K. Schöler.** (Ann. d. Physik, 45. 6. pp. 913–928, Nov. 3, 1914. Extract of Dissertation, Kiel.)—By means of the modified Kundt's tube method described by Behn and Geiger [Abs. 249 (1908)] the author has determined the ratio of specific heats of a number of gases at pressures ranging from ⅓ to 3⅔ atmos. Corrections to the results obtained on the supposition that the gases were ideal were made by means of the observations of Regnault and Winkelmann on the deviation from Boyle's law. All the gases showed increasing values of the specific heat ratio with increase of pressure, the effect being small, however, for those gases far removed from their points of liquefaction at the temperature of the experiment. F. J. H.

469. *Cooling of a Wire and Lorenz's Formula.* **V. M. Schidlovski.** (Russian Physico-Chem. Soc., J. 46. 3. pp. 132–136, 1914.)—Various investigators, among them Hartmann and Tereschin [Abs. 3217 (1904), 1241 (1905)], have shown that the loss of heat by a horizontal stretched wire corresponds well, over a wide range of temperature, with Lorenz's formula (Wied. Ann. 13. p. 582, 1881), $Q = A(T^4 - T_0^4) + B(T - T_0)^{5/4}$, where T and T_0 are the respective absolute temperatures of the heated body and of the surrounding medium and A and B coefficients which are constant for given experimental conditions. The case of a vertical wire does not seem to have been tested, and the author has therefore made measurements with a polished Pt-wire, 43·2 cm. in length and 0·05 cm. in diam., stretched first horizontally and then vertically. For the horizontal position, the observations are in good agreement with Lorenz's formula, the values of the constants being (1) $A' = 2{\cdot}589 \times 10^{-12}$ and $B' = 2{\cdot}897 \times 10^{-3}$, when the loss of heat is expressed in cals. from the whole surface of the wire, or (2) $A = 0{\cdot}25 \times 10^{-12}$ and $B = 2{\cdot}81 \times 10^{-4}$, when the loss of heat is given in watts per cm. length of the wire. These values differ somewhat from those obtained by Tereschin (*loc. cit.*), who employed a wire with a matt surface. When the wire is vertical, observations are less easy and the curves connecting the temperature with the square of the current are less smooth than with a horizontal wire. The results are, however, in satisfactory agreement with Lorenz's formula. In the latter the first term of the right-hand side gives the loss of heat by radiation and the second term the loss due to convection and conduction, so that the value of A′ may be assumed to be the same for a vertical as for a horizontal wire. If this is done, the calculated values of B′ vary only between $2{\cdot}27$ and $2{\cdot}64 \times 10^{-3}$, the mean value being $2{\cdot}44 \times 10^{-3}$. The diminished loss by convection and conduction, indicated by the lower value of B′ for the vertical wire, results from the ascending hot air-currents enveloping the wire. The current sufficient to heat the vertical wire to redness leaves the horizontal one dull. T. H. P.

470. *Theory of Free Gaseous Spheres.* **C. T. Bjalobrsheski.** (Russian Physico-Chem. Soc., J. 46. 3. pp. 137–162, 1914.)—Previous investigators, in dealing with the theory of free gaseous spheres, have neglected to take into consideration the part which may be played by the pressure of radiant energy in the internal equilibrium of gaseous spheres. In the present mathematical paper, the author shows that, where the mass of a gaseous sphere is comparable with that of the sun or stars, the pressure of radiant energy is of preponderating importance. All the magnitudes, namely, the pressure, temperature, and density, which determine the condition at any point are functions solely of the distance from the centre, but in the case of the sun, this is not exactly true, owing to its rotation about its axis. In spheres of constant density the pressure of the rays in the centre is of greater importance than in so-called polytropic spheres having the value 4/3 for c_p/c_v or γ. In passing from the centre to the surface, the pressure of the gas diminishes, for constant density, proportionally to the first power of the temperature, whereas the decrease of the radiation-pressure is proportional to the fourth power of the temperature. In polytropic spheres, with $\gamma = 4/3$, the ratio of the pressure of radiation to the gaseous pressure remains constant throughout the whole extent of the sphere and only near the surface should it diminish as a result of the transparency of gases with low densities. If radiant energy were left out of account, a sphere of constant density might be regarded as a polytropic sphere with $\gamma = \infty$. Spheres for which γ has values between ∞ and 4/3 should exhibit intermediate properties. It may therefore be concluded that in polytropic or adiabatic spheres, for which $\gamma = 5/3$ or 7/5—monatomic and diatomic gases in the case of adiabatic spheres—the pressure of radiant energy in the central regions plays a greater rôle than in those for which $\gamma = 4/3$. T. H. P.

471. *Static Method for Determination of Difference between the Vapour Pressure of Solution and that of Solvent.* **J. C. W. Frazer** and **B. F. Lovelace.** (Am. Chem. Soc., J. 36. pp. 2439–2449, Dec., 1914.)—A novel method, based on Rayleigh's differential manometer, is used to determine the difference of vapour-pressure between a pure solvent and a solution. By carefully removing all the air, and maintaining the temperature of solvent and solution constant within 0·001 deg. C., it is maintained that differences of vapour-pressure can be established to about 0·001 mm. T. M. L.

472. *Apparent Thermodynamic Discontinuities in connection with the Value of the Quantity* b *for Infinitely Large Volume.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 17. pp. 606–615, Nov. 7, 1914.)—A further discussion of the questions dealt with in Abs. 1553 (1914).

473. *Emissivity of Metals and Oxides.* I. *Nickel Oxide.* **G. K. Burgess** and **P. D. Foote.** (Bureau of Standards, Bull. 11. pp. 41–64, 1915.)—Making use of the wedge method described by Mendenhall [Abs. 770 (1911)], the author has determined the monochromatic emissivity of nickel oxide at various temperatures within the range 700° to 1300° C. By means of a spectrophotometer of the Lummer-Brodhun type, observations were made for the wave-lengths $0·5\,\mu$, $0·6\,\mu$, and $0·7\,\mu$ respectively. The wedge-shaped nickel strip was heated in a specially constructed furnace, and determinations of the relative intensities of the light emitted by the outside and inside of the wedge were made. The apparent emissivity of the oxide layer diminished with continued heating owing to the outside temperature being reduced by the increasing thickness of the layer; the true emissivity was obtained by extrapolating to zero thickness. It was found that the monochromatic emissivity increases linearly with increasing wave-length throughout the visible spectrum, but decreases linearly with rise of temperature. Determinations of the emissivity for $\lambda = 0·65\mu$ made with a Holborn-Kurlbaum type of Morse pyrometer by the method of microscopic melts agreed with the above spectrophotometric determinations. The total radiation from a nickel oxide surface was also measured by twelve pyrometers of various types. The total emissivity was found to increase with temperature throughout the range 600° to 1800° C., the increase being practically linear between 700° and 1200°.

The paper includes correction curves and tables for use with total radiation pyrometers of various kinds. F. J. H.

474. *Specific Heat of Copper between 0° and 50° C., with a Note on Vacuum-jacketed Calorimeters.* **D. R. Harper.** (Bureau of Standards, Bull. 11. pp. 259–329, 1915.)—The specific heat of chemically pure copper between 0° and 50° C. has been redetermined with precision on account of its importance in some determinations of the mechanical equivalent of heat which are being undertaken, the thermal capacity of the copper in these experiments amounting to 1 or 2 % of the whole. A new method is adopted in which 50 m. of copper wire 2·5 mm. in diam. serves the fourfold function of being the test specimen, the calorimeter itself, the heater, and the thermometer. The wire in the form of a non-inductive coil is suspended in a vacuum and heated with a measured quantity of energy supplied electrically, the resulting temperature-rise being measured by the increase in resistance. The results of 27 determinations at temperatures between 15° and 50° show an average deviation of one part in a thousand from the value given by $S_t = 0{\cdot}388_4 + 0{\cdot}00020\,(t - 25)$ international joules per gm. degree. The paper includes a survey of all the measurements of the specific heat of copper which have been published hitherto. Appended to the paper is a discussion of the use of the vacuum jacket as a means of reducing the cooling correction in calorimetry, the magnitude of the heat transferred by conduction through the air in various stages of rarefaction being compared with that transferred by radiation from some of the more commonly used surfaces. The note is intended to indicate the degree of exhaustion it is profitable to obtain for a given set of fixed radiation conditions when thermal insulation by means of a vacuum jacket is planned. F. J. H.

475. *Measurements on Standards of Radiation in Absolute Value.* **W. W. Coblentz.** (Bureau of Standards, Bull. 11. pp. 87–100, 1915.)—In the first part of the paper measurements are given of the radiation from the Hefner lamp and from a standard sperm candle relative to that of a black body. The radiation from these standard sources is given in absolute values on the assumption that the radiation constant is $5{\cdot}7 \times 10^{-12}$ watt cm.^{2} deg.$^{-4}$, which is practically the mean value of the best present-day determinations. The data are considered to be useful for rough calibrations of radiometers in absolute measure. For refined measurements of radiation a standardised glow-lamp is recommended for this purpose.

In the second part, data are given which show the precision which can be attained in standardising such a glow-lamp against a black body, thermopiles of widely different constants being used with concordant results. The importance of specifying the intensity of a radiation stimulus in absolute units so that an experimenter's work can be repeated is emphasised, the use of a standard glow-lamp being advocated for this purpose. In a supplementary note a description of preliminary measurements of the radiation constant of a black body by means of a modified form of Ångström pyrheliometer is given. The mean value of 50 measurements is $5{\cdot}61 \times 10^{-12}$ watt cm.^{2} deg.$^{-4}$.

F. J. H.

SOUND.

476. *Architectural Acoustics.* **W. C. Sabine.** (Frank. Inst., J. 179. pp. 1-20, Jan., 1915.)—In order that hearing may be good in any auditorium it is necessary that the sound should be *sufficiently loud;* that the simultaneous components of a complex sound should maintain their *relative intensities,* and that the *successive sounds* in rapidly-moving articulation, either of speech or of music, should be *clear and distinct,* free from each other and from extraneous noises. These three are the necessary and entirely sufficient conditions for good hearing. Scientifically the problem involves three factors: reverberation, interference, and resonance. As an engineering problem it involves the shape of the auditorium, its dimensions, and the materials of which it is composed.

Sound, being energy, once produced in a confined space, will continue until it is either transmitted by the boundary walls or is transformed into some other kind of energy, generally heat. This process of decay is called absorption. Thus, in the lecture-room of Harvard University, in which this investigation was begun, the rate of absorption was so small that a word spoken in an ordinary tone of voice was audible for 5½ secs. afterwards. During this time even a very deliberate speaker would have uttered 12 or 15 succeeding syllables. Thus the successive enunciations blended into a loud sound, through which and above which it was necessary to hear and distinguish the orderly progression of the speech. Across the room this could not be done, nor even near the speaker except with an effort wearisome in the extreme if long maintained. With an audience filling the room the conditions were not so bad but still intolerable.

This may be regarded as a process of multiple reflection from walls, ceiling, and floor, losing a little at each reflection until ultimately inaudible. This phenomenon will be called reverberation, including as a special case the echo. In general, reverberation results in a mass of sound filling the whole room and incapable of analysis into its distinct reflections. It is thus difficult to recognise and locate. In the general case of reverberation we are concerned only with the rate of decay of the sound. This rate of decay was gauged by measuring what is inversely proportional to it: the duration of audibility of the reverberation or residual sound. Broadly considered there are two, and only two, variables in a room: shape (including size) and materials (including furnishings). In designing an auditorium an architect can give consideration to both; in repair work for bad acoustic conditions it is generally impracticable to change the shape, and only variations in materials and furnishings are allowable. This was, therefore, the line adopted in this case. It was evident that the rate at which the reverberation would disappear was proportional to the rate at which the sound was absorbed. The first task was accordingly to determine the relative absorbing power of various substances. With an organ-pipe as a constant source of sound, and a suitable chronograph for recording, the duration of audibility of a sound after the source had ceased in this room (empty) was found to be 5·62 secs. All the cushions from the seats in Sanders Theatre were then brought over and stored in the lobby. With a total length of 8 2 m. of cushions the duration fell to 5·33 secs. With 17 m. it was 4·94 secs. When all the seats (436) were covered, the sound was audible for only 2·03 secs. By covering the aisles and platform and putting the other cushions round the room on a scaffolding till the whole (1500) were used, the duration fell to 1·14 secs.

The method was arranged so as to give not relative, but absolute, coefficients of absorption of sounds an octave above middle C as follows :—.

Material.	Coefft. of Absorption.
Oil paintings and frames	0·28
Carpet rugs	0·20
Oriental rugs, extra heavy	0·29
Cheese cloth	0·019
Cretonne cloth	0·15
Shelia curtains	0·23
Hair-felt, 2·5 cm. thick, 8 cm. from wall	0·78
Cork, 2·5 cm. thick, loose on floor	0·16
Linoleum, loose on floor	0·12

In the following table the absorption of each object is expressed in terms of 1 sq. m. of complete absorption :—

Object.	Absorption per sq. m. of object.	Object.	Absorption per sq. m. of object.
Audience	0·44	Plain ash chairs of bent wood	0·0082
Isolated woman	0·54	Upholstered settees, per single seat	0·28
Isolated man	0·48	Upholstered chairs	0·30
Plain ash settees, per single seat	0·0077	Hair cushions, per seat	0·21

For the materials of walls, floors, and ceilings the following were obtained :—

Material.	Coefft. of Absorption.	Material.	Coefft. of Absorption.
Open window	1·000	Glass, single thickness	0·027
Wood sheathing (hard pine)	0·061	Plaster on tile	0·025
Plaster on wood lath	0·034	Brick set in Portland cement	0·025

On plotting graphs with duration as ordinates and total absorbing material as abscissæ the curves are equilateral hyperbolæ. If curves for various buildings are plotted it is found that the parameters of these curves (the constant product of abscissa and ordinate) are directly proportional to the volumes of the buildings in question.

The variation of duration with pitch of sound was also investigated. The spreading of sound from the centre of an auditorium and its subsequent reflection was also carefully examined, and the intensities all over determined and plotted in plan like contour-lines on a map. Models of the building were also made, a sound started in it, and then instantaneously photographed. Eight such photographs are included in the original paper.

E. H. B.

477. *Influence of Length of Wind Tube on the Pitch and Intensity of Tones of Reed Pipes.* **J. R. Ewald.** (Ann. d. Physik, 45. 8. pp. 1209–1216, Dec. 8, 1914.)—With the arrangements shown in a diagram it was found that for continually increasing lengths of wind tube (to convey the blast from the wind chest) the pitch of the reed pipe in use periodically fell from its normal value, 680, to 660 (or even 640), and rose again to its normal value. The normal values corresponded to an even number of quarter-wave lengths in the pipe, the abnormal values to an odd number. Together with the falling-off of the frequency was associated an even more striking diminution of intensity of the sound. These effects are shown in tables and graphs in the paper. It is concluded that stationary waves occur in the wind tube. E. H. B.

478. *Artificial Hiss.* **E. B. Titchener.** (Am. Phil. Soc., Proc. 53. pp. 323–329, Aug.–Dec., 1914.)—In *Nature* of May 29, 1913, it was asked how to make an artificial hiss. The present author replied that if Köhler's observations are correct, a Galton whistle, set for a tone of 8400 vibrations per sec., will give a pure *s*. This has now been experimentally tested with an Edelmann-Galton whistle, actuated by a black rubber bulb slightly more flaccid than that furnished by Edelmann. Bulbs of white or grey sulphur-coated rubber are unsuitable, as the fine dust chokes the mouthpiece and plays havoc. The sounds of the whistle and those of an *s*, or hiss, made by the human mouth, were sounded in various orders a large number of times, and observers not knowing what to expect, were called upon to judge which sounds were due to the mouth and which to the whistle. In the final tests the mistakes were about 35 %, the mouth being judged as whistle slightly oftener than the reverse. The mouth sound was phonetically shown to be an English *s* or hiss, and the whistle sound was found by Kundt's dust-figures to be between 8594 and 8522, and by Edelmann's tables, etc., to be about 8430 vibrations per sec. [See Abs. 1312 (1913).] E. H. B.

479. *Fog Signals.* **E. O. Catford.** (Engineer, 119. pp. 129–130, Feb. 5, 1915.)—A few years ago it was commonly held that sound is unaffected by fog, but that view is now considered open to question by the author, who sends notes on his observations during the past 5 years at the Platte Fougère Fog Signal Station, Guernsey, 20 miles from Alderney and 26 miles from Jersey, at each of which places the signal is often heard, though at other times it is inaudible at the power station just over a mile away.

The general conclusions arrived at are briefly as follows :—(1) When both fog signal and observer are immersed in the *same* bank of fog little interference with sound may be experienced. (2) If the fog signal is in fog and the observer in clear atmosphere, or *vice versa*, *great* interference with sound may be expected, still more so if the signal is in one fog bank and the observer in another bank. (3) A bank of fog will often reflect sound so strongly and definitely that its distance can be calculated from the known velocity of sound, and this calculation will agree with a visual estimate of the distance.

The observation of a silent zone succeeded by a more distant zone in which the sound is audible is explained by a different temperature gradient above the fog from that ruling in the fog itself. Hence some of the lower sound is refracted steeply down close to the source and some of the higher sound is very slightly refracted, thus reaching the sea-level a considerable distance away. Thus between the inner and outer zones of audibility a zone of silence intervenes. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS AND ATMOSPHERIC ELECTRICITY.

480. *Theory of the Metallic State.* **F. A. Lindemann.** (Phil. Mag. 29. pp. 127–140, Jan., 1915.)—The outstanding physical properties of metals are now attributed to the presence of a number of so-called free electrons in the interstices between the atoms, and the author discusses, in this connection, electrical and thermal conduction, specific heat, contact potential, the thermoelectric, Peltier and Richardson effects, reflection, and the photoelectric, Hall, Thomson and Nernst-Ettingshausen effects. It is concluded that the free electrons in a metal may not be treated as a gas, since a gas can conduct heat well only if its capacity for heat is large. Experiment proves that the free electrons conduct heat well but that their heat capacity is too small to admit of measurement. The assumption of a large free path to compensate for the small number of electrons leads to contradictions with the optical properties of metals. It is suggested that the free electrons in a metal form a space-lattice, which corresponds with a crystal at a very low temperature, as the small mass of the electrons leads to a high frequency. The point of view from which this theory would explain the various phenomena is indicated. Although the exceptional behaviour of alloys and the general outlines of the photoelectric effect are explained in this way, special assumptions are necessary to arrive at the Wiedemann-Franz law; the contradictions entailed by the older theory do not arise. T. H. P.

481. *Unipolar Induction.* **S. J. Barnett.** (Ann. d. Physik, 45. 8. pp. 1253–1256, Dec. 3, 1914. From the English.)—A reply to the views of Fehrle on this subject [see Abs. 510 (1914)]. E. H. B.

482. *Electrostatic Intensity on a Conducting Sphere in a Uniform Field of Force.* **G. R. Dean.** (Electrician, 74. pp. 602–603, Feb. 5, 1915.)—The solution of this problem by the method of images is given in several textbooks on electricity and magnetism. The author shows that the problem can also be solved by adjusting solutions of Laplace's equation to certain boundary conditions. I. W.

483. *Repulsion of Two Metallic Discs.* **C. Barus.** (Am. J. Sci. 39. pp. 93–104, Jan., 1915.)—Deals with a continuation of some experiments described in a former paper [Abs. 1179 (1914)]. The author shows definitely the presence of a repulsion between two metallic discs which are separated by very short distances. (The max. distance was about 1 mm.) He has also been able to balance this repulsion against the attraction produced by charging the two plates to a suitable potential by means of a battery. Curves and tables are given showing how the forces vary with the distances between the discs. I. W.

DISCHARGE AND OSCILLATIONS.

484. *Direct Magnetic Determination of Photoelectric Velocity Distribution.* **C. Ramsauer.** (Ann. d. Physik, 45. 7. pp. 961–1002, Nov. 17, 1914.)—(1) A method is here developed for determining the speed distribution of the photoelectrically liberated electrons for a given direction of emission and throughout a wide spectrum. (2) The method consists in the magnetic deflection of the emitted electrons by a uniform field. (3) The illumination was produced by the spectrally-dispersed light from a spark. (4) The utility of the method is seen by the values it gives for e/m; mean value $1{\cdot}75 \times 10^7$ c.g.s.; extreme values, $1{\cdot}69 \times 10^7$ to $1{\cdot}81 \times 10^7$. E. H. B.

485. *Photoelectric Velocity Distribution and its Dependence on Wave-length.* **C. Ramsauer.** (Ann. d. Physik, 45. 8. pp. 1121–1159, Dec. 3, 1914.)—The data of this experimental research were obtained by the author's direct magnetic method [preceding Abs.]. The materials and spectral regions dealt with were as follows :—

Zinc	334–186 $\mu\mu$;	extreme value 368 $\mu\mu$.
Brass	285–186 $\mu\mu$;	extreme value 318 $\mu\mu$.
Gold	256–186 $\mu\mu$;	extreme value 275 $\mu\mu$.
Carbon	252–186 $\mu\mu$;	extreme value 266 $\mu\mu$.

(1) The distribution curve of volt-velocities in the normal direction for the electrons emitted by any one given material, the abscissa of its maximum height being taken as unity, is of a form independent of the frequency of the exciting light. (2) For zinc, brass, and gold these distribution curves are nearly identical. (3) The distribution curve consequently gives a function which is characteristic of the photo-effect. Its form is compared with five functions which on mathematical or physical grounds appear probable. (4) The distribution curve has quite straight rising and falling portions. A definite highest velocity does not exist. (5) The volt-velocities of the most copiously emitted electrons for zinc, brass, and gold form a *linear* function of the frequency. (6) This function leads to a line distinctly curved if plotted against the *square* or the logarithum of the frequency. (7) The straight lines for the zinc, brass, and gold are approximately parallel. (8) The point at which the straight portions aim, is the *extreme* value of the photoelectric effect. The quantity of emitted electrons for the extreme value is therefore zero. (9) Carbon showed an abnormal behaviour, in that the curve of volt-velocities as a function of the frequency possesses a flat maximum. E. H. B.

486. *Electric Vibrations in Gas as disturbing Factor in Kathode Rays.* **O. Devik.** (Ann. d. Physik, 45. 6. pp. 941–960, Nov. 3, 1914.)—In this experimental work the propagation of electric waves in the gas of the vacuum tube is first studied in its rôle as a disturbing factor to the kathode rays; secondly it is sought to formulate the conditions in which the kathode-ray work may be carried out free from such disturbance. Various other points are also brought under discussion, such as the reflection or scattering of the kathode rays.
E. H. B.

487. *Sparking Potentials at High Pressures.* **F. Hayashi.** (Ann. d. Physik, 45. 3. pp. 431–453, Sept. 15, 1914.)—The behaviour of the spark discharge in gases at high pressure has been the subject of much experiment, but the results so far obtained are by no means in accord. The determination of the dependence of the spark potential in different gases at pressures between 1 and about 75 atmos. is the object of the present experiments. The chief sources of error are shown to be the Warburg "spark delay," and the chemical alteration of the gas in consequence of the passage of the spark. The want of agreement between the results obtained by previous workers, as well as the manner in which the present results differ from the earlier ones, is no doubt owing to the fact that sufficient notice has not been taken of these sources of error. The most important results now obtained are as follows:— Paschen's law does not hold for high pressures. The relation between the increase of the discharge potential and the increase of pressure is not a linear one. With pressures between 10 and 75 atmos. the curve representing the connection between potential and pressure is approximately parabolic; under 10 atmos. the curve becomes the more nearly linear as the pressure is lowered. For different gases the bend of the curves differ; sometimes the curves for two gases intersect: thus the curves for oxygen and CO_2 cut those for air and nitrogen. In a mixture of two gases the value of the spark potential lies between the values for the individual gases and is proportional to the ratio in which they are mixed. A. E. G.

488. *The Cosine Law of the Arc Crater.* **A. Amerio.** (Elettrotecnica, 2. pp. 12–14, Jan. 5, 1915.)—Experiments were made to ascertain whether the light and the total energy radiated by the crater of an arc follow the cosine law. The results of the experiments show that in both cases this law is followed. For the light the experiments were made with a Lummer-Brodhun photometer by comparison with an ordinary glow-lamp. For the total energy a thermo-couple and a galvanometer were employed. E. B.

489. *Stationary Hertz Waves in Air, and Speed of Propagation in Air and along Wires.* **M. Sjöström.** (Ann. d. Physik, 45. 3. pp. 358–376, Sept. 15, 1914.)—An experimental research in continuation of previous work and using the same oscillation and room. A thermo-couple of iron and constantan is used as the detector, and it was established that, within the limit of experimental errors, the speed of propagation is the same along wires and in the air. [See Abs. 738 and 1440 (1914).] E. H. B.

490. *The Arc as a Source of Oscillations.* **F. Mercer.** (Phys. Soc., Proc. 26. pp. 372–380; Disc., 380, Aug., 1914. Electrician, 74. pp. 216–217, Nov. 20, 1914. Abstract.)—Describes some experiments.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

491. *Intermittent Conductivity of Thin Plates of Dielectric.* **E. Branly.** (Comptes Rendus, 159. pp. 785–789, Dec. 14, 1914.)—A thin leaf of mica, paper, or gelatine is placed between two quite plain discs of metal, usually of cobalt or copper, and pressed until a very feeble conductivity is established. Alternate and intermittent currents were tried. The latter caused no increase of conductivity. E. H. B.

492. *Electrical Resistance of Mercury, Tin, Cadmium, Constantan, and Manganin at Liquid-helium Temperatures.* **H. K. Onnes** and **G. Holst.** (K. Akad. Amsterdam, Proc. 17. pp. 508–518, Nov. 7, 1914. Comm. No. 142*a* from the Phys. Lab., Leiden.)—A further contribution on this subject [see Abs. 1121 (1914)]. (1) *Resistance of wires of solid mercury.*—Several mercury resistances were compared with the Pt-resistance thermometer, first in liquid oxygen, and then at other temperatures (4·19° K. to 234·16° K.), with the differential galvanometer according to Kohlrausch's method. The tabulated values of the resistances, as observed and as calculated on the assumption that the resistance diminishes linearly from the melting-point down to the absolute zero, show differences which are not by any means constant: the deviation is a maximum at about 138° K. The relation between resistance and temperature is thus of a very complicated character. (2) *Change in resistance at melting-point.*—The ratio of the resistance in the liquid state to that in the solid state was found to be 4·66; with a larger-section thread, 4·50. A value 5·06 has been found for the calculated value of this ratio, in agreement with Baltruszajtis' figure, 4·90 [Abs. 671 (1913)]. Resistance values are also given for pure cadmium and for copper and iron. *Constantan.*—The temperature coefficient of constantan, which is extremely small even down to oxygen temperatures, increases considerably in the region of the hydrogen temperatures, so that constantan wires are suitable for use as thermometers in the region of helium temperatures and also in the hydrogen region, where the Pt-thermometer would require complicated calibrations. *Gold.*—With a view to investigating the suitability of the gold-resistance thermometer in the region of oxygen and hydrogen temperatures the resistance of a gold wire was determined at a great number of temperatures in those regions. The results show that in the region of the reduced oxygen temperatures (mainly below − 200° C.) the Au thermometer does not give rise to the difficulties which make the Pt-thermometer nearly worthless in that region. L. H. W.

493. *On the Theory of the String Galvanometer of Einthoven.* **L. S. Ornstein.** (K. Akad. Amsterdam, Proc. 17. pp. 784–793, Dec. 24, 1914.)

ALTERNATING CURRENTS AND MAGNETISM.

494. *Structural Changes in Iron and Chromium Compounds at High Temperatures.* **K. Honda** and **T. Soné.** (Tôhoku Univ., Sci. Reports, 3. pp. 223–234, Aug., 1914.)—The compounds Fe_3O_4, Fe_2O_3, CrO_3, and Cr_2O_3 were examined in air by means of a method previously employed for work on manganese compounds [Abs. 350 (1915)]. The susceptibility-temperature curves were obtained for the substances for a temperature range from − 190° to 1300° C. In hematite, the susceptibility increases rapidly about − 40°, then more slowly after 0° to a maximum about 575°, afterwards falling rapidly to a low value at 690°. The magnetite powder examined was previously heated above 600° to remove remanent magnetism. On cooling, the critical temperature was 680°, and a curve was obtained somewhat similar to that for hematite. Similar work was done with the chromium oxides. It is concluded that at 1300° C. hematite does not change its structure, but that at this temperature magnetite changes almost completely to hematite. Further, chromic oxide does not change at this temperature, and the changes in chromium trioxide similarly heated are:—

$$CrO_3 \longrightarrow Cr_6O_{15} \longrightarrow (Cr_5O_9 \longrightarrow) \; Cr_2O_3.$$

G. E. A.

495. *Influence of Molecular Constituents and Temperature on Magnetic Susceptibility.* I.–III. **A. E. Oxley.** (Roy. Soc., Phil. Trans. 214. pp. 109–146, May 5, 1914, and 215. pp. 79–108, 1915.)—In Parts I. and II. the author shows that the change of specific susceptibility, which accompanies the transition from the liquid to the crystalline state for many substances, can be satisfactorily interpreted in terms of a *mean* molecular field which operates to an appreciable extent only in the crystalline state. This molecular field can be regarded as a magnetic field limited to such a magnitude as to produce in the molecules of the substance a distortion, or polarisation, such as is equivalent to that actually produced by the mutual forces of the molecules of the crystalline structure. The minimum value of the mean molecular field in some diamagnetic crystalline media is large compared with that in liquids.

In Part III. an estimate of the intensity of the local molecular field in crystalline media is obtained from the small variation of χ which occurs on crystallisation. From the 40 substances investigated the existence of an intense local molecular field of the order 10^7 gauss, if interpreted magnetically, is indicated in those diamagnetic substances which show a measurable change of χ on crystallisation. [Part III. has already been briefly treated in the paper dealt with in Abs. 1789 (1914).] L. H. W.

496. *A Magnetograph for measuring Variations in the Horizontal Intensity of the Earth's Magnetic Field.* **F. E. Smith.** (Phys. Soc., Proc. 26. pp. 279–290 ; Disc., pp. 290–291, Aug., 1914.)—In the case of unifilar instruments for recording variations in H, if θ is the angle which the magnetic system makes with the magnetic meridian, M the moment of the magnet, and H the horizontal intensity of the earth's field, equilibrium results when $MH \sin \theta = T\phi$, where ϕ is the torsion on the fibre and T is a constant. In the instrument described ϕ may be made great or small, but high sensitiveness is secured by making ϕ great. The magnet system is supported by a quartz fibre, and critically aperiodic damping is obtained by means of an Al vane and two parallel damping plates. To diminish the sensitiveness the effective length of the fibre may be reduced. The general usefulness of the instrument is illustrated by photographic records, which show the instrumental peculiarities to be very small, and indicate that unless the system is aperiodic increased difficulty must result in the interpretation of the records. An over-damped system responds but slightly to rapid pulsations in H, but follows the slow changes which are common all over the world. The general sensitiveness of the records is about 8 mm. for a change in H of 0·00001 c.g.s. unit, but one record shows a displacement of 8 mm. for such a change. AUTHOR.

RADIOGRAPHY AND ELECTROPHYSIOLOGY.

497. *Modern Apparatus for Instantaneous Radiography.* **U. Magini.** (N. Cimento, 8. pp. 203–212, Sept., 1914.)—After a brief introductory note the following are some of the points dealt with: Apparatus with closed magnetic circuit ; Apparatus with coil and interrupter ; Pseudo-instantaneous apparatus with coil and Wehnelt interrupter. A short account of original work on pendulum and electromagnetic interrupters is also given. A. E. G.

498. *Unsymmetrical Alternating Currents for Röntgen-Ray Tubes.* **J. L. Farny.** (Schweiz. Elektrot. Verein, Bull. 6. pp. 1–14, Jan., 1915.)—By an adaptation in the construction of the transformer it is possible to obtain a three-fold increase in the max. current fed to the Röntgen tubes without increasing the size of the special machine, with the same weight of copper and about double the weight of iron in the transformers. The steps which led up to this result are described. The results also show that the improvement of the output must no longer be attempted by diminishing the capacity of the transformer while simultaneously increasing its secondary tension.

A. E. G.

499. *Exact Localisation of Projectiles in the Human Body by Radiography.* **E. Colardeau.** (Comptes Rendus, 159. pp. 783–788, Nov. 30, 1914.)—The method described is simple and rapid, and the necessary accessories are easily made. Diagrams illustrating the method are given, as is also the calculation of the exact position of the foreign body by the system of co-ordinates used. By using tables calculated from the given formulæ it is possible in less than 5 minutes after obtaining the radiographs to locate the projectile and determine its depth. A. E. G.

500. *Localisation of Projectiles in the Human Body by Radiography.* **H. Bertin-Sans** and **C. Leenhardt.** (Comptes Rendus, 159. pp. 803–804, Dec. 14, 1914. Archives d'Él. Médicale, 23. pp. 11–17, Jan. 10, 1915.)—The problem is to find two points, A and P, on the skin which define a line passing through the projectile, and to determine the distance p of the latter from either A or P as is most convenient. A method is described by means of which it is possible to determine such a line and also the distances Ap and Pp. A. E. G.

501. *Determination of Positions of Projectiles in the Human Body by Radioscopy.* **F. de Courmelles.** (Comptes Rendus, 160. pp. 97–100, Jan. 18, 1915.)—The method described is an adaptation of that of F. Hernaman-Johnson which was intended for use with limbs only. It is more rapid than that method and can be used in a general manner for any part of the body. In place of using only one ring, two are now employed, each of which is suitably mounted on a thin wooden support. A radioscopic view of the body is first obtained. Then one ring is placed in front and the other behind, surrounding the foreign body, and the position on the skin of the centre of each ring is marked. Sufficient data are thus obtained for locating the foreign body, and an example of the method of doing this is worked out. A. E. G.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

502. *Density of Lead from Ceylon Thorite.* **F. Soddy.** (Nature, 94. p. 615, Feb. 4, 1915.)—A short time ago the author published the result of an examination of the relative atomic weight of a quantity of lead, less than 1 gm., separated from Ceylon thorite: this specimen of lead gave a value rather more than a unit in excess of that found for a specimen of ordinary lead. More recently, however, a specimen weighing about 80 gm., and an equal weight of ordinary assay lead, have been carefully purified by identical processes and their specific gravities accurately determined. On the view that the atomic volumes of isotopic elements should be identical, it is to be expected that the densities should be in proportion to the atomic weights. The density of ordinary lead, purified in the manner described was found to be 11·3465 ($D^{20°}_{4°}$), all the determinations agreeing within 8 units in the last figure. On the other hand, the value found for the specimen of thorite lead was 11·376, *i.e.* 0·26% greater, and higher than has been found previously in any trustworthy determination. The atomic weight calculated from the density is therefore 207·64, if 207·10 is taken as the atomic weight of ordinary lead. Bismuth, if any at all was present, comprised less than 1 part in 10^7 of the mineral. This strongly opposes the view that Bi is one of the end products of the Th series. A. B. W.

503. *Calculation of the Molecular Dimensions from the Supposition of the Electrical Nature of the Quasi-elastic Atomic Forces.* **J. J. van Laar.** (K. Akad. Amsterdam, Proc. 17. pp. 877–884, Jan. 28, 1915.)—The dependence of b on the volume is apparently somewhat complicated but its variation with the temperature is expressed by the simple relation, $[b_g-(b_0)]/(b_0)=0·041\sqrt{T}$, in which $(b_0)=v$, extrapolated from the direction of the so-called straight diameter at T_k [see Abs. 1284, 1558, 2004 (1914)]. This relation agrees perfectly with that given by a formula drawn up by van der Waals, namely, $[p+a/v^2+A(b-b_0)](b-b_0)=fRT$, in which A represents the spatial constant of quasi-elastic forces—which were taken as proportional to the increase of volume, $b-b_0$—and f is a coefficient depending on the number of degrees of freedom. The simplest assumption concerning A is that the quasi-atomic forces are brought about under the influence of two elementary charges, e. Close agreement is found between the value of the molecular magnitude calculated on the basis of this assumption and those derived for various substances from the van der Waals equation of state and the temperature coefficient of $(b_g-b_0)/b_0$. T. H. P.

504. *Quantitative Determination of Radium.* **H. Schlundt.** (Am. Electrochem. Soc., Trans. 26. pp. 163–171; Disc., 171–179, 1914.)—The paper commences with a discussion on the relative merits of the various methods of separation and collection of RaEm from the ore, the Ra-content of which is required. Two standard methods of separating the emanation from the specimen are outlined: (1) The "solution" method, and (2) the "fusion" method, introduced by Joly [Abs. 1414 (1911)]. The author states that the results obtained by the fusion method are generally higher than the values by the solution method. In the latter case it is difficult to avoid forming slight precipitates in the solutions, and these probably cause the separation of some Ra which does not release its emanation completely on boiling. Since the apparatus designed by Joly is rather expensive, experiments have been directed towards devising and testing the accuracy of a simple fusion method which can be conducted with inexpensive apparatus. For a description of this apparatus and the various methods used for separating and collecting the emanation the original paper must be consulted. Tables containing the results from analyses of the following minerals are given: Uraninite, carnotite concentrate, carnotite ore, spring deposit. In all, 12 different methods of separating the emanation have been employed and the mean value of a number of determinations by each method is given. From a consideration of the tables the author draws the following conclusions:—(1) The solution method, that is, fusion with mixed carbonates, followed by solution and boiling, gave results that are only 70 to 80% of the values obtained by the fusion method with mixed carbonates. (2) Fusion with mixed carbonates appears to be superior to fusion with potassium acid sulphate. (3) Fusion with borax probably gives a low result as a result of the retention of some of the emanation in the "melt." At the temperatures attained in the experiments the evolution of gas, and its flow through the melt, is necessary for complete release of the emanation. (4) High emanating power in the cold indicates a large release of emanation by heating. In the case of a specimen of carnotite ore a rough assay may be made by merely heating to bright redness. (5) A complete separation of the emanation from uraninite is obtained by solution in nitric acid and by fusion with some of the ordinary fluxes.—No experiments were conducted with the resulting fused mass to ascertain whether the equilibrium quantities of emanation can be again separated by a subsequent fusion. In the *discussion*, **S. C. Lind** gave a short account of his determinations of the Ra/Ur ratio in carnotites, obtaining results by the solution method 10 to 20% low, in agreement with the results mentioned above. He also found that the fusion method, successful with carnotites, is a complete failure under the same conditions for crude sulphates, whilst the solution method succeeded with pitchblende but failed with carnotites. These observations render the variety of methods described in the present paper all the more valuable. **W. G. Brown** communicated a brief *résumé* of some experiments on this problem which he had carried out in collaboration with O. E. Sheppard. Their determinations by solution in sulphuric and nitric acids are in fair agreement with the results obtained in the present experiments, but the lower values by fusion with mixed carbonates stand in direct contrast to the higher values of the author. A. B. W.

505. *Binary Copper-Zinc and Ternary Copper-Zinc-Lead Alloys.* **N. Parravano** [with **C. Mazzetti** and **R. Moretti**]. (Soc. Chim. Ital., Gazz. 44. 2. pp. 475–502, 1914.)—The melting-point diagram for Cu-Zn alloys differs from those of Shepherd [Abs. 2774 (1904)] and of Carpenter and Edwards [Abs. 1264 (1911)] only as regards the equilibrium horizontals at 905°, 833°, 700°, 595°, 545°, and 425°, for which the corresponding durations have been determined. The temperature of the eutectoid transformation, $\delta \longrightarrow \gamma + \epsilon$, which the author finds to be 545°, was given by Shepherd [*loc. cit.*] as 450° and by Tafel [Abs. 1718 (1908)] as 550°. T. H. P.

506. *Manganese-Cobalt Alloys.* **K. Hiege.** (Zeitschr. Anorg. Chem. 83. pp. 253–256, Nov. 4, 1913. Rev. de Mét. 11. E. pp. 527–528, Aug., 1914.)—The cobalt was free from Ni, the Mn prepared by the thermit process; the alloys were prepared by fusing the two metals in a hydrogen atmosphere in a tube of Haldenwanger porcelain. As with Ni, Mn gives with Co an uninterrupted series of mixed crystals. Only the beginning of the crystallisation was fairly distinct; the freezing curve has a flat minimum at about 1160° for 80 % Co; the crystals are not homogeneous, but become so by annealing in magnesia in a hydrogen atmosphere for 5 hours at 1000°. The magnetic transformation temperature falls with increasing Mn percentage almost regularly. On cooling the temperatures are:—For 60, 70, 80, 90, 100 % Co: 950°, 1010°, 1050°, 1105°, 1150°. The alloys become sensibly magnetic when the Co percentage exceeds 40. H. B.

507. *Nickel-Palladium Alloys.* **F. Heinrich.** (Zeitschr. Anorg. Chem. 83. pp. 322–327, Nov. 4, 1913. Rev. de Mét. 11. E. p. 530, Aug., 1914.)—The palladium used was chemically-pure wire 0·5 mm. in diam. The metals were prepared by fusion in tubes of Haldenwanger porcelain. The determination of the freezing-point curve was rendered difficult by superfusion, especially in the alloys rich in Ni. The curve is asymmetrical in its two branches, and has a flat minimum near 1208°; mixed crystals exist in all proportions. When the polished surfaces are etched with nitric acid, the corrosion decreases in the order: alloy, Pd, Ni; alloys with 86 % Pd are most rapidly attacked. In determining the temperature at which the magnetism vanishes, the alloy is suspended, in front of the electromagnet, from the thermo-couple (Pt–Rh) by means of a Pt-wire which is drawn into a slit sawn in the alloy. The magnetic susceptibility is not much affected by small percentages of Pd; above 40 % Pd there is a decided fall; at 87 % Pd the material appears non-magnetic; at 80 % the temperatures of change on heating and on cooling coincide. There is no difference in structure between the magnetic α and the non-magnetic β-crystals. Alloys rich in Ni are malleable. H. B.

508. *Allotropy of Cadmium.* IV. **E. Cohen** and **W. D. Helderman.** (K. Akad. Amsterdam, Proc. 17. pp. 638–641, Nov. 27, 1914.)—Hulett's low-voltage standard cells [Abs. 1763 (1914)] sometimes have an e.m.f. of 0·048 volt at 25°, and in those cases where the e.m.f. is originally 0·050 volt, this decreases spontaneously to the constant value, 0·048 volt. On the assumption that the voltages 0·047, 0·048, and 0·050 correspond with cells containing α-, β- and γ-cadmium respectively, at temperatures above the transition-point of the change, α-cadmium $\rightleftarrows$ β-cadmium—which is found by dilatometric measurements to be about 60°—the e.m.f. of α-cells must be higher than that of the β-cells, whilst, after cooling below this transition-point, the contrary must occur. Measurements of the e.m.f. of the two cells at 25° and at 64·5° show that this is actually what takes place. It is therefore concluded that the e.m.f. 0·048 volt at 25° is to be attributed to the presence of β-cadmium in the cell. T. H. P.

509. *The Allotropy of Antimony.* **E. Cohen** and **J. C. van den Bosch.** (K. Akad. Amsterdam, Proc. 17. pp. 645–647, Nov. 27, 1914.)—Hitherto the following 4 allotropic modifications of antimony have been recognised: (*a*) metallic Sb crystallising in the hexagonal system, (*b*) black Sb obtained by rapidly cooling antimony vapour, (*c*) yellow Sb obtained by the interaction of antimony hydride with air, oxygen, or chlorine, and (*d*) explosive Sb. As a preliminary to an investigation of the relationships existing between these various forms the authors have carried out density and dilatometric determinations on pure Sb cast in a chill cooled in a mixture of alcohol and solid

CO_2. The results indicate that chilled antimony constitutes a metastable system consisting of more than two allotropic forms. There appears to be a transition-point in the neighbourhood of 101° C., but the temperature of this transition also seems to depend on the previous thermal history of the sample. F. C. A. H. L.

510. *The Allotropy of Lead.* **E. Cohen** and **W. D. Helderman.** (K. Akad. Amsterdam, Proc. 17. pp. 822–828, Dec. 24, 1914.)—Indications of the existence of allotropic forms of lead are to be found in chemical literature of even before the Christian era. The authors have kept powdered lead in a solution of lead acetate containing a small quantity of nitric acid, for 8 weeks at a temperature of 15° C. After this time the density had increased by 17 units in the third place of decimals. The sample was then re-immersed in the solution and kept at a temperature of 50° C. for a period of 120 hours, after which time its density had decreased by 28 units. After a repetition of the experiment at 25° C. for 144 hours the density rose by 15 units in the third place of decimals. These observations were confirmed by dilatometric observations, and indicate that there are more than two allotropic modifications capable of simultaneous existence in a sample of lead. If pieces of stable and metastable lead be immersed in the above electrolyte it is possible to promote the growth of a lead tree in the solution. F. C. A. H. L.

511. *Metastability of Metals in consequence of Allotropy and its Significance in Chemistry and Physics.* **E. Cohen** and **G. de Bruin.** (K. Akad. Amsterdam, Proc. 17. pp. 926–934, Jan. 28, 1915.)—In Abs. 129 and 987 (1914) it has been pointed out that the existing data on the mechanical and physical constants of metals are fictitious, since they have been determined on indefinite metastable systems. The true specific heat of molten Na can be reproduced with great accuracy, while in the case of solid Na, discrepancies of 2 % at the same temperature were observed in the earlier experiments of the authors. Determinations have been made at various temperatures, of the specific heats of samples of Na which had been very slowly cooled, and also on others which had been quenched from a temperature well above the melting-point. The results show that the specific heat of Na is a function of its previous thermal history, and that both with the slowly cooled and the chilled metal it is possible to obtain reproducible values of the constant at any particular temperature. At 0° C., the value for the perfectly annealed sample is 0·2829, and for the quenched specimen 0·2870. Intermediate treatments give values between these two limits. Sodium is therefore to be regarded as an enantiotropic substance with a transition temperature lying between 0 and 90° C., the exact position of which will have to be determined by dilatometric measurements. F. C. A. H. L.

512. *Removal of Sulphur from Silver.* **C. C. Bissett.** (Chem. Soc. J., Trans. 105. pp. 2829–2836, Dec., 1914.)—The removal of sulphur from metallic silver by fusion with potassium nitrate is tedious, the oxidation proceeding slowly. Results obtained by additions of copper and of iron, and also by blowing air through the molten metal, are given. The addition of small quantities of copper is found to cause part of this metal to alloy with the silver, the remainder replacing some silver in the silver sulphide, forming cuprous sulphide which dissolves in the excess of silver sulphide present in the mixture. From the experiments it was found that copper was of little value for removing sulphur from silver. The experiments with

additions of iron showed that this metal was capable of removing sulphur from silver when sufficient was added to saturate the whole of the sulphur present. On blowing dry air through silver containing silver sulphide, the removal of sulphur is found to proceed slowly, over 40 minutes being required to remove the sulphur from 30 gm. of silver containing 16 % of silver sulphide. C. O. B.

513. *Surface Potentials of Solutions in Contact with Insulators.* **G. Borelius.** (Ann. d. Physik, 45. 6. pp. 929–940, Nov. 8, 1914.)—In the experiments here described, use has been made of the multiplying device previously mentioned [see Abs. 1171 (1914)], but the metallic electrodes have been replaced by normal calomel electrodes, in order that no doubt should exist as to the magnitude of the electrode potential. A glass vessel was employed, in one case clean and in the other coated internally with a thin layer of paraffin wax. It is found that the surface potentials of aqueous solutions may exhibit variations of several tenths of a volt and the deviations from Nernst's law for the electrode potentials (*loc. cit.*) are to be attributed to such variations. Several of the regularities previously observed are therefore to be ascribed, not to electrode processes, but to surface phenomena. With a given electrolyte, the surface potential towards paraffin is proportional to the logarithm of the ionic concentration or of the conductivity. This law is similar to that of Nernst for the electrode potentials of metals in solutions of their salts—namely, electrode potential $=$ const. $+ 58 \log c/n$ millivolts, where n is the valency and c the concentration of the metallic ions; the values of the constant are of the same order of magnitude as, but somewhat smaller than, those of Nernst. For solutions of an acid, the surface potential towards glass is proportional to the logarithm of the concentration of the hydrogen ion; thus, for HCl, $P = 254{\cdot}5 \times 58{\cdot}4 \log x \times 10^{-5}$ millivolts. Addition of a neutral salt produces no alteration in the surface potential of water. With solutions of a base, the potential diminishes with increasing hydroxyl-ion content, *i.e.* with diminution in the concentration of the hydrogen ions, but the diminution does not follow the law just given for acids. These phenomena are, however, modified very appreciably if small amounts of impurity are adherent to the glass surface; an exception to this is found in the case of potassium cyanide solutions, which keep the glass surface clean. T. H. P.

514. *E.M.F.'s and Electrode Potentials in Mixed Solvents.* **J. N. Pearce** and **W. H. Farr.** (Journ. Phys. Chem. 18. pp. 729–758, Dec., 1914.)—The electrode potentials of silver in solutions of silver nitrate in water, ethyl alcohol, methyl alcohol, and in binary mixtures of these solvents were determined at 0° and 25°. The electrode potentials are greatest in methyl alcohol and least in aqueous solutions. The values are highest in the most concentrated solutions; they decrease rapidly with dilution at first and then almost linearly with further dilution. The electrode potentials in binary mixtures of the two alcohols obey the law of mixtures. In binary mixtures of water and the two alcohols, they increase slowly from the value in pure water up to mixtures containing about 75 % of the alcohol and then more rapidly with further increase in the proportion of alcohol. The e.m.f.'s of all the possible concentration cells in the above solvents were determined and compared with those calculated from the electrical conductivities by means of the Nernst equation. From the agreement between the observed and calculated e.m.f.'s it was concluded that the Nernst equation can be applied to non-aqueous solutions and to binary mixtures of solvents.

The heats of ionisation of silver were calculated as follows :—

Ethyl alcohol	+ 22,727 cals.	50 water, 50 ethyl	+ 24,292 cals.
Methyl alcohol ...	+ 23,126 cals.	50 water, 50 methyl ...	+ 24,541 cals.
Water	+ 24,062 cals.	50 ethyl, 50 methyl ...	+ 22,973 cals.

T. M. L.

515. *Hermann's Phenomenon.* **G. S. Walpole.** (Roy. Soc., Proc. 91. pp. 134–147, Jan. 1, 1915.)—In 1887 Hermann showed that when a current is passed from a dilute solution of a salt to one more concentrated, acid is liberated at the boundary layer, and that alkali is set free at the same place when the current is passed in the opposite direction. The author has made experiments which have confirmed and extended the observations of Hermann. A special form of transport apparatus, designed to facilitate the formation and investigation of the boundary layers, was made use of. The results show that the quantities of acid and alkali liberated bear no relation to the amount of current passed. The acid, no matter what neutral salt is used, is always liberated where the current passes from the more dilute to the more concentrated solution; the alkali is always liberated where the current passes from the concentrated solution to that more dilute. Other conditions being the same, a constant amount of acid and alkali is liberated, no matter what neutral salt be used. The quantities of acid and alkali developed (in the apparatus used) increase with time and then become constant. The explanation suggested by the author is based on the difference in velocity of the hydrogen and hydroxyl ions on opposite sides of the boundary layer. This difference is determined by the fall of potential per unit length, which depends essentially on the conductivity of the two solutions. The quantities of acid and alkali set free can be calculated from the potential gradients in the solutions on each side of the boundary, the time for which the difference of potential is maintained, the resistance constant of the vessel employed, the dissociation constant of water, and the known migration velocities of the hydrogen and hydroxyl ions. The actual experiments afford numbers that are in approximate agreement with the calculated quantities, which, in all cases, are exceedingly small. T. S. P.

516. *Electrolytic Preparation of Potassium Ferricyanide.* **G. Grube.** (Zeitschr. Elektrochem. 20. pp. 334–344, 1914.)—The electrolytic oxidation of potassium ferrocyanide (yellow prussiate) to ferri salt (red prussiate) is studied in glass cells with clay diaphragms and electrodes of Ni, Pt, Cu, Fe, lead peroxide. At 18° with a current density of 0·005 amp./cm.^{2} at the anode a current efficiency of 94·5 % was realised; higher current densities reduce the current efficiency, which is independent of the nature of the anode. Technically it is important, however, that Ni anodes are attacked when the ferro-salt contains any impurities besides alkali. Chlorine in particular is deleterious. The best temperature is 50° C.; above 50° the alkaline ferri-solution is partly decomposed, and iron oxide deposited on the anode, so that the internal resistance rises. When the anode compartment is kept saturated with ferro-salt, the ferricyanide is directly obtained in crystals. This is the great advantage of the electrolytic over the (otherwise cheaper) oxidation by means of chlorine; the latter process yields a solution of ferricyanide and potassium chloride, which salts are difficult to separate by crystallisation.

H. B.